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The ILLUMINATING ENGINEER

·ELECTRICITY· ·ACETYLENE· ·OIL· ·GAS·

Edited by LEON GASTER

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OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London 1909.)

This number contains an account of the Discussion on ***"Visibility; Its Practical Aspects,"*** initiated by Messrs. C. C. Paterson and B. P. Dudding at the last meeting of The Illuminating Engineering Society, on April 27th.

Among other items there are several articles dealing with ***"Industrial Lighting,"*** and a summary of a recent paper by Prof. R. A. Gregory, entitled ***"Science in the Daily Press."***

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EDITORIAL.

Factory Lighting in War Time.

During the nine months that have elapsed since the outbreak of war there have been gigantic industrial changes. This has been a period of general activity. Factories previously devoted to munitions of war have been spurred to new efforts, and are working at the utmost pressure. Others have been converted to military and Government work and are rapidly adapting themselves to entirely new conditions ; others, again, are striving with depleted staffs and broken connections to make good the havoc caused by the interruption of customary channels of trade. Everywhere in this country there is unceasing work—even in those cases in which the commercial loss has been heavy.

In view of these facts the lighting industry should not lose the opportunity of pressing home the value of good industrial illumination. Outside

lighting at the present time, especially in London, has been badly hit; factory lighting provides an opportunity of recouping, to a considerable extent, the loss in this direction.

The paper by Mr. A. E. Broadberry before the Eastern Counties Gas Managers' Association on Thursday, April 29th, gave an encouraging account of experience in Tottenham, where there are many large factories. From the writer's professional experience he can corroborate Mr. Broadberry's remark that the pressure of extra work and long hours has been the means of impressing upon factory owners the economic value of proper industrial illumination.

All must recognise the great progress made both in high pressure gas lighting and in the modern varieties of electric lighting, but at this stage we do not wish to enter into comparisons between the two illuminants. As the author pointed out the question is a very complex one, and one cannot base such comparison only on the cost and efficiency of the lamps. The flexibility of the system of lighting, the capacity for bringing lamps near the work, the possible appications of gas or electricity for driving machinery, heating, &c., and other local conditions often influence the decision. One must also bear in mind the special nature of the operations in the factory, and consider whether general illumination or local lighting by separate small units are needed. These are factors which often favour one or the other illuminant. We may mention in passing a very enterprising step recently taken by the Tottenham and Edmonton Gas Company, namely, the supply of electricity in one section of their area. Consumers in this district can thus make a choice between the two illuminants supplied by the same company.

One feature in Mr. Broadberry's paper we should like to emphasise—the figures given for the illumination available in the working plane. It is now recognised that data respecting the candle-power of lamps alone are not sufficient and that they should be supplemented by measurements of illumination. We are glad to see that gas and electrical engineers both accept this view; by the publication from time to time of such data we shall gradually acquire a knowledge of the requirements of various industrial processes. We should like, however, to see such investigations extended considerably and carried out by recognised independent experts. In making comparisons of the merits of different systems of lighting it is desirable that examples of the most recent and up-to-date installations should be taken in both cases. It would, for example, be a mistake to compare the most up-to-date electric installation with an antiquated gas installation or vice versa. This is important not only from the public standpoint but in the interests of those representing the competing illuminants, since without such impartial investigation, they are naturally not in a position to determine where the advantages of their systems lie, and in what directions they can be most usefully employed.

The writer could mention several instances of high pressure gas lighting installations in which excellent results have been obtained.

Another point brought out by many of the striking photographs shown by Mr. Broadberry was the value of proper methods of shading. At the present time good factory lighting, both gas and electric, involves the careful distribution of light on the goods, and makers of both types of lamps now recognise this fact. We are glad to see that the introduction of the electric "Half-Watt" lamp has already been followed by the design of a variety of suitable reflectors.

Visibility—its Practical Aspects.

The discussion on this subject initiated by Mr. C. C. Paterson and B. P. Dudding at the last meeting of the Illuminating Engineering Society, proved a useful supplement to the discussion on searchlights last February. We have here two distinct aspects of the subject, (1) the physical problem of the brightness of the searchlight beam and (2) the physiological problem of the impression received by the eye from the distant illuminated object. Prof. Blondel, in his exhaustive contribution in our February and April issues, has shown how closely these two aspects are correlated, and the discussion at the last meeting again illustrated how many practical problems there are into which these physiological considerations enter. The appearance of distant coloured lights (such as ships' lights, railway signals, &c.) the effective value of motor-car and locomotive headlights in revealing obstructions on the road or line, the effect of shadow and contrast in determining the appearance of small objects illuminated by direct and indirect light—all these are problems in which the illuminating engineer is naturally interested.

Another important point touched upon by the authors was the effect of bright lights in causing glare. Dr. Ettles pointed out that quite a variety of factors play a part in such cases—notably the state of adaptation of the eye. A person who has spent some time in a dark room is dazzled even by the light of a match, the glaring effect of which would be inappreciable in daylight. Here the colour of the light is of some consequence in view of its effect on the peripheral region of the retina—a point which was shown by Dr. Watson to have a bearing on the conditions by night experienced by the soldiers in the trenches.

Another matter of topical interest is the rating of the power of headlights and searchlights. In the present circumstances the authorities are faced by a particularly difficult problem in determining when lights exceed the permissible limit. Naturally cases of inconsistency occur. There seems a need for some simple and practical method of testing the power of headlights, and it is possible that, as a result of theoretical researches, some simple method of this kind could be contrived. This is one of those cases in which special technical assistance is badly needed. We understand that the Motor Car Association are attempting the solution of the problem and it is probable that the Illuminating Engineering Society, whose members are accustomed to the estimation and measurement of the illuminating power of sources of light, might be able to render effective assistance.

Finally one may refer to another important application of the principles of visibility, namely, the art of rendering objects inconspicuous to the enemy. The selection of soldiers' uniforms has been the subject of considerable study on the part of the nations engaged in the present war. When one considers, too, that the effectiveness as scouts of certain branches of the service, submarines, aircraft, &c., depends largely on their being as inconspicuous as possible one realises the importance of scientific researches in this direction. The authorities are naturally engrossed in the tremendous task of carrying on the war, and have no leisure to initiate such researches, but this should not be the case in the future and even at present it is possible that something useful might be effected by the organised efforts of scientific non-combatants.

Science in the Daily Press.

On pp. 203—207 in this issue we give an account of the paper read by Professor Gregory, Assistant Editor of *Nature*, before a recent meeting of the Circle of Technical, Scientific and Commercial Journalists, on the above subject. Prof. Gregory quotes some amusing instances of popular errors which have appeared in the daily press, and many of those present at the meeting were able to give similar cases of mistakes on technical and engineering matters. It is a curious anomaly that references to technical and scientific matters in the daily press not infrequently contain errors which would never be tolerated in respect to legal, literary or political matters. Inventions which would not for a moment stand criticism at the hands of a scientific audience, are described in glowing and sensational terms. Events of high importance in the scientific and engineering world are passed over or presented in a superficial or incorrect manner.

In the present circumstances such mistakes are easily made. There are several leading dailies which employ a technical staff and know where to turn for first hand information on scientific subjects. Others, however, have not these facilities and it is hardly surprising that paragraphs on unfamiliar subjects hastily compiled by journalists with no scientific knowledge should lack accuracy and precision. Something is needed to bridge the gulf between the scientist and the ordinary public. The daily press could render great services to science by making its aims more widely known and securing for it a larger place in the estimation of the people. It has often been urged as a reproach against this country that it did not appreciate scientific knowledge and research at their true value, that it lagged behind other countries in the encouragement of the applied science. Let us hope that one result of this unhappy war will be to bring about a change in this respect.

The most natural channel of information on scientific and technical matters is the journalist who devotes his time to these subjects. The editor of a technical paper, if not a literary genius, has at least a working knowledge of his subjects and understands the needs of the industry with which he is brought in contact. He, therefore, is the man to whom the daily press should most naturally apply in time of need. Most papers, we believe, would go to considerable trouble to ensure that their information was correct, and they are patriotic enough to welcome suggestions as to how the scientific and technical resources of the nation could best be utilised.

At the March meeting it was suggested that articles on important scientific and technical subjects should preferably be signed by a responsible journalist ; or, if unsigned, that they should be referred to a reader having a special knowledge of the subject in question. Arrangements are being made to prepare, from the members of the Circle, a list of gentlemen willing to act as readers of articles dealing with their special subjects. There are many cases in which their services would doubtless be appreciated by the daily press, and a little more co-operation between the technical journalist and the daily press should prove most beneficial to our industries.

This matter is of special importance to the lighting industry since the relative merits of lighting appliances are particularly liable to misrepresentation.

Surely the public have a right to be kept fully informed as to the value of the appliances they are using in order that they may appreciate and take advantage of genuine improvements in the art of illumination.

LEON GASTER.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of "The Illuminating Engineer."

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

CONTRACTS FOR FACTORY LIGHTING.*

A very interesting paper on the above subject was read at the last Annual Convention of the Illuminating Engineering Society in the United States by O. R. Hogue and A. O. Dicker.

The Commonwealth Edison Company in Chicago has adopted a special method of charging for electricity supplied to factories in that city. In the form of contract there are three charges: for (1) rental, (2) maintenance, (3) electricity. One great advantage of this is that it meets the case of the factory manager who believes in improved lighting but finds a difficulty in meeting the high first cost of installation. Accordingly, the company makes a practice of undertaking to install the lighting equipment on the most up-to-date lines, and the cost is spread over a period of two years, at the end of which the installation becomes the property of the consumer.

Not only this, but the company also undertakes the maintenance, furnishing a ten-day cleaning service, renewing all burned-out lamps, and keeping the installation in good working order. This is covered by the maintenance charge which, however, is not made during the months of June, July, and August.

The advantage of this system of control is obvious. The installation is carried out on standard principles, and it is to the company's interest to see that the onsumer is satisfied and that the conditions of illumination are adequate for the work in hand. In addition the company does not lose sight of an installation, but keeps it in good order, recommends changes from time to time as improvements in lighting appliances are introduced, and generally ensures that an originally good installation does not suffer from neglect. The importance of this can be understood from the recent researches of Mr. C. E. Clewell* who shows that the accumulation of dust on shades and lamps in factories, during three weeks' neglect, may cause a 50 per cent. diminution in illumination.

The authors illustrate their paper by a complete series of data on a number of typical installations. The cost of installation in the examples quoted varies from \$2.76 (11s. 6d.) to \$9.88 (£2 2s.) per unit.

The "total cost per square foot per month" varies from 0·156 cents (·08d. approx.) to 1·440 cents (·72d.).

* "Factory Lighting" by O. R. Hogue and A. O. Dicker, Transactions of the Illuminating Engineering Society, Vol. 9, 1914, p. 86.

* Factory Lighting.

ELECTRIC LIGHTING OF METAL WORK PLANTS.

A RECENT paper before the American Illuminating Engineering Society on this subject by A. L. Powell and R. E. Harrington* serves to show the variety of metal working operations with which the expert lighting engineer has to deal. Below we tabulate some of their suggestions for different branches of work. Naturally in the paper fuller details are given.

Besides attending to the general requirements of such shops as regards avoidance of glare and inconvenient shadows, freedom from flickering, &c., it is necessary to study these operations in detail and to select both the reflector and the positions of lamps with care. The following table will give an idea of the variety of operation and the consumption of electricity usually found necessary.

METAL WORKING OPERATIONS.

Nature of Work:—	REMARKS.	Watts per sq. foot.
ORE WORKING—		
Crushers	General even illumination impracticable; adequate lighting of passages and at special points where work is done (racks, separators, hoists)	—
Concentrators		
Racks, etc.		
EXTRACTION—		
Smelting	In furnace work only sufficient illumination for safety, repairs, charging, &c.	—
Blast furnaces		
Puddling „		
Crucibles		
Bessemer Converters	In electrolytic work even general illumination preferred	0·2—0·5
Open Hearth Furnaces ..		
Electrolytic Refining		
METAL WORKING—		
Casting—		
Moulding		
Core-making		
Charging cupolas		0·5—1·0
Pouring	Good general illumination for large work	
Tumbling	Local lighting at benches	
Cleaning, chipping, etc. ..		
Rolling—		
Shingling		
Steam Hammers	General illumination	0·35—0·65
Rolling (various operations)		
Forging—		
Hand Anvil		
Machine, drop and press ..	General or "Localised General" illumination	0·3—1·0
Tempering and Hardening		
Cutting or Machine Tool Work—		
Lathes		
Planers		
Shapers and Slotters ..	General or "Localised General" illumination	0·3—1·4
Drilling and Boring ..		
Milling machines		
Grinding		
Saws		
Bench Work	ditto	0·35—1·45
Wire Working—		
Cold Drawing		
Weaving	ditto	0·3—0·75
Twisting		
Finishing		
Sheet Metal Working—		
Punching		
Pressing		
Shearing	ditto	0·35—1·05
Spinning		
Buffing		
Assembly	General	0·4—1·2
Erection and Testing ..		
Painting		

* Trans. Illum. Eng. Soc. U.S.A. Vol. 9. pp. 833—838, 1914.

FACTORY LIGHTING BY HIGH PRESSURE GAS.*

By A. E. Broadberry (Tottenham).

At a meeting of the Eastern Counties Gas Managers' Association, a paper on the above subject was read by Mr. A. E. Broadberry, of Tottenham.

In the earlier portion of the paper Mr. Broadberry pointed out the importance of good industrial lighting at the present moment, when so many factories are working at high pressure on Government work.

At the present time, he said, owing to the huge demand for arms, munitions, clothes, and food-stuffs for the war, many factories are working throughout the night as well as during the day.

The efficient lighting of these works, consequently, has become a matter of extreme importance, and experience shows us that the officials having charge are keenly interested in any scheme which will enable them materially to increase the output of work by means of a better lighting of their factory.

That good lighting does increase the output, he added, there can be no shadow of a doubt. It enables men to do their work as quickly, as accurately, and (above all) as cheerfully by night as by day. I have put cheerfulness above all, because I think everyone will admit that there is more tendency to despondency when working at night, and despondency is the worst possible state of mind for producing either speed or correctness in any class of work.

Factories which are at the present time working at night—even taking the district of the Tottenham Company as a criterion—are very varied as regards shape, build, and class of industry, and naturally their requirements in regard to ideal lighting must vary for the same reasons. From the nature of their structure or their work, some require general diffused lighting; but in other trades what is usually known as "point," or "spot," lighting is far more important, if not actually essential.

* Abstract of paper read before the Eastern Counties Gas Managers' Association, April 29, 1915.

As an instance of recent high pressure gas installations, Mr. Broadberry mentioned the works of Messrs. Millington & Sons, Ltd., at Tottenham Hale.

The problem to be faced was that, in addition to an area of 39,000 superficial feet for stock-rooms and secondary buildings which had to be lighted at a lower luminosity, a floor area of 51,000 superficial feet, containing a multitude of machines for envelop folding, gumming, printing, ruling, cutting, punching, embossing, type composing, and many other purposes, besides dozens of tables for sorting, labelling, &c., &c., had to be efficiently lighted, and shadows on the work itself had to be avoided as much as possible.

The lamps used consisted of 142 100-candle-power, 299 150-candle-power, 28 300-candle-power, and 10 500-candle-power; the latter being used for lighting the outside of the factory. The tested consumption showed 1,300 cubic feet of gas used per hour, and a consequent cost, at 2s. per thousand cubic feet, of 2s. 7d. per hour for the entire installation, or 0·43d. per thousand candles per hour.

The lamps were so placed as to give the best light on the work. Some photographs were shown illustrating the lighting, but Mr. Broadberry considered that no photograph could do complete justice to the very gratifying result, which must be seen to be properly appreciated. "Indeed, the excellent lighting makes a very striking impression on every visitor; but still more is he surprised when told the low cost per hour for this brilliant lighting. He then readily appreciates that the cost is repaid over and over again by the more efficient work which can be produced with good lighting, as compared with that which is produced with an inferior one."

The lighting effect in foot-candles of surface illumination was tested by the Lumeter, and gave the following results:—

(1) Machine tables, 5 foot-candles.
Do. do 3·5 foot-candles.

This gives an average reading of about 4·5 foot-candles over the whole of the machine tables.

(2) On machines, 4·7, 3·6, and 5·2 foot-candles.

This will give a mean reading of 4·5 foot-candles on all the machines.

(3) Envelope folder and gumming:—

	foot-candles.
Bench	4·5
Shadow—*i.e.*, position where envelopes are counted	1.0
Ruling machines	8·1
Feed side of ruling machine	6·8
Folding Bench	3·8
Litho machine	3·2
Wharfedales	6·8

(4) Compositors' frames:—

The general readings taken in the centre of the lower frames was 8 foot-candles.

Approximately, the height of each lamp from the working plane to the mantle would be 4 feet, but, of course, it would vary as the height of the working surface varied.

For the sake of comparison, figures were also given for the portion of the factory lighted by electricity.

In passing, it is interesting to observe that in another section of its area the Tottenham Gas Company supplies both electricity and gas; consumers therefore can take their choice, selecting which illuminant is suitable to the local circumstances.

FIG. 1.—Messrs. Pentony and Co.'s Factory.

In the Tottenham district there are many other examples of industrial gas lighting. The following figures in the woollen underclothing factory of Messrs. Sussmann, Ltd., are also interesting. The total floor area is 5,978 superficial feet, and the total candle-power 11,115. Readings for surface illumination are given in the following table:—

	foot-candles.
Sewing Department machines	11·5
Between machines	10·5
Ironing table (directly under 300 c.p. fitting)	15·0
Do. do. do. do.	12·5
Half-way between above fittings (distance about 6 feet)	5·5

	foot-candles.
On ironing table between 300 c.p. lamps (about 8 feet 6 inches high)	5·0
Weaving benches	10·5
Directly underneath fitting (150 c.p.) ..	16·5
Do. do. do. do. ..	11·5
Do. do. do. do. ..	16·0
Do. do. do. do. ..	17·0
Between two fittings	13·5
Sewing machines	

This reading was taken between two lamps approximately 6 ft. 6 in. from ground level.

	foot-candles.
On working parts of looms	8·0
Do. do. do.	7·5
Do. do. do.	8·0
Do. do. do.	7·8
On floor—	
Gangway between rooms	5·5

FIG. 2.—Messrs. Hobson and Sons' Army Clothing Factory.

Needle	7·7
Between two machines	12·5
Random readings taken at second machine table	10·0
Do. do. do. do. do.	11·5
Do. do. do. do. do.	12·5
Do. do. do. do. do.	13·2
Do. do. do. do. do.	14·5
Do. do. do. do. do.	13·0
Cutting bench (directly under 300 c.p. fitting, about 5 feet from working plane)	7·3
At an angle of about 45°	5·5
Second cutting bench, directly underneath	5·2
At an angle of about 45°	5·5
Weaving rooms and looms—	
On floor	4·5

It will be interesting for members to know that high-pressure gas-irons are used in this factory for pressing the work before packing, and they perform their work to the entire satisfaction of the management.

Fig. 1 shows the lighting of the factory of Messrs. Pentony & Co., where the floor area is 13,000 square feet, and the total candle-power is 19,100. The work carried on in this factory is, among other things, ladies' blouses, ladies' leather belts, gentlemen's ties, portable pails, haversacks, &c.

The readings for surface illumination give the following results :—

	foot-candles.
Eye-letting table (under 150 c.p. decorative fitting)	3·5
Eye-letting table (under 1,000 c.p. suspension lamp)	10·5
Table by eye-letting machine	4·5
Sewing machine	9·0
Do. do.	4·5
Do. do.	8·0
Do. do.	7·5
Needle	4·5
Cutting bench	6·5
Do. do.	10·25
Ironing table	1·8
Do. do.	3·1
Do. do.	2·3
Needle	1·5
Do.	·8
Cutting bench (150 c.p. deep shade) ..	6·5
Do. do. (150 c.p. flat shade) ..	4·75
Goffering machine (500 c.p. fitting) ..	7·5
By goffering bench	4·0

One peculiar feature of these figures is the shading of the lamps with cardboard boxes, on account of the fact that the daylight lighting of the factory is effected by means of the saw-tooth principle of roof. This large surface of glass necessitates the shading of the lights to satisfy present police regulations. Gas-irons are also largely used in this factory.

Among other instances of factory lighting Mr. Broadberry mentioned the Army Clothing Factory of Messrs. Hobson & Sons, in the South Metropolitan Gas District.

The paper was illustrated by a variety of excellent photographs, two of which we are reproducing on pages 200 and 201.

Discussion.

The President (Mr. W. B. Farquhar) remarked that in Mr. Broadberry's District there were a large number of factories erected, so that he had special opportunities of doing work on a large scale. High pressure gas lighting, however, could also be successful on a small scale and any gas undertaking could give as much satisfaction in one factory, as in half a dozen.

Mr. J. S. Dow said that Mr. Leon Gaster, who had been present earlier in the proceedings by invitation, had unfortunately had to leave before Mr. Broadberry's paper was read. Mr. Gaster had read the paper with interest and he (Mr. Dow) wished to say a few words on his behalf.

As a member of the Departmental Committee on Factory Lighting, Mr. Gaster was naturally interested in data on industrial illumination. At the present time one could not say much about the work of the Committee, but it was hoped that it would be of considerable service in stimulating public interest in this question.

As Mr. Broadberry had pointed out, it was a complex matter to make comparisons between various methods of lighting. One had to take into account other things beside the cost and efficiency of the lamps, such as flexibility and other considerations depending on the nature of the work carried out in a factory. He was glad to see that the author had given a series of figures for the actual illumination on the working plane; this seemed necessary as a basis of comparison as well as the candle-power of the lamps. He would also like to congratulate Mr. Broadberry on the series of photographs shown.

Mr. W. Townsend (Colchester) congratulated Mr. Broadberry on his paper, which was of special interest as showing there were opportunities for lighting, even at the present time.

He would like to know whether any trouble from glare had been experienced with these powerful lights: the illustration seemed to differ in this respect, the lights being more completely shaded in some cases than in others. Another point was flexibility. Had moveable fittings been used with any of those high pressure lamps? At Colchester they had had experience of certain shops with high cranes, above which the lamps had to be fixed. Reliable means of raising and lowering high pressure lamps were therefore desirable.

He could confirm what Mr. Broadberry said as to the importance of good lighting in factories during the present urgent work on munitions of war.

Mr. Broadberry, in reply to Mr. Townsend, pointed out that the exposed lights were of relatively small candle-power, mainly 100 and 150 candle units. Lamps were from time to time tested, but in factories it was not practicable to test every individual lamp.

Movable fittings could be obtained, though they were not employed in this case, and there was also available fittings for enabling lamps to be raised or lowered so that cranes could pass.

Mr. Broadberry added that tests of illumination had been made with the "Lumeter" both by natural and artificial light. The latter value did not approach those obtained in bright sunshine.

SCIENCE IN THE DAILY PRESS.*

By Professor R. A. Gregory, F.R.A.S.

Judging from statements commonly made in newspapers—not only in daily papers but also in weekly periodicals in which greater accuracy might reasonably be expected—there are few literary people who have a knowledge of natural objects and phenomena equivalent to that of children in the State schools. It is scarcely too much to say that, omitting signed articles written by experts, few newspapers make any announcement relating to a scientific subject without committing a mistake. Either terms are wrongly used, or a matter of common knowledge among men of science is regarded as a remarkable discovery, or observations of a sensational kind are presented to the public as if they were established truths, though they await confirmation from the scientific world, and are mostly unworthy of serious consideration.

It seems to be too much to expect literary people to possess an elementary knowledge of science, or to have any sympathy with scientific precision. but it is not unreasonable to ask for accuracy of description when they are dealing with natural facts and phenomena. They may reply that Shakespeare was often at fault in matters pertaining to natural history; but he at any rate reflected in his works the best knowledge of his time, which is more than can be said of most writers to-day.

We are often told that men of science should cultivate the art of literary expression, but the stronger necessity for literary men to have at least a nodding acquaintance with the outstanding facts of natural knowledge is overlooked. A well-known author has unkindly said, "The man of science appears to be the only man in the world who has something to say, and he is the only man who does not know how to say it." The retort invited by this remark is that the man of letters frequently has nothing to say, and he says it at great length. The first business of the man of science is to create new knowledge, and not necessarily to clothe his discoveries in a pleasing dress, though he may do so. The facts of science provide material upon which literary art may be exercised, but the two functions of exploration and fine expression are rarely found together.

The methods of accurate observation and cautious interpretation demanded of scientific investigators do not readily lend themselves to attractive description, and the results require more mental concentration to understand them than is usually demanded of a literary performance. A writer of romance can let his imagination have free play, but when natural occurrences enter into the story they should be presented accurately, if the material is to be used rightly. It is the easiest thing in the world to be deceived by appearances, or to accept a belief without inquiry into its foundations; the scientific plan of asking for evidence, and of limiting statements to those for which good justification can be produced, is much more tiresome, yet it is the only way by which truth can be attained; and that after all is the highest aim.

Misconception as to the cause and character of many common phenomena

* **Abstract of Paper read before the Circle of Scientific, Technical, and Commercial Journalists, Feb. 23rd, 1915.**

in Nature; the tendency to accept statements without inquiry into the credentials of the author or independent investigation of the facts; and the view that science is an esoteric study beyond the comprehension of most people, are almost as prevalent now as they were in former times. The book of Nature is open for all to read, yet few look into it and fewer try to understand what is written.

There is a common impression that the conclusions arrived at by men of science are of the nature of beliefs, and have, therefore, no firmer basis than that of conviction. Nothing could be farther from the truth. From his earliest days the student of science is trained to ask for evidence before arriving at a judgment; and he should hesitate to pass an opinion upon a subject with which he is not familiar. Any beliefs he may hold as to natural phenomena belong to quite a different category from that of knowledge gained by the critical examination of observed facts. No subject is too trivial for inquiry, and no relationship must be regarded as impossible from *a priori* considerations, but the scientific mill must have material to work upon before the value of the product can be estimated. It is permissible to doubt whether the grain is worth grinding, but not to deny it a trial; for without a test any belief may be held as to its quality. Whether you doubt or believe is of no consequence whatever in scientific things if you cannot give reason for the position you occupy. There must be facts and there must be thought about them before any statement of substantial value can be made as to natural objects and phenomena.

Popular impressions and beliefs relating to weather are often based upon casual observations, and have little foundation in fact. Yet every belief of this kind is worthy of examination, and if it has not been investigated no man of science is justified in asserting that it is untrue. But when such an inquiry has been made, and the evidence has failed to support popular opinion, we cannot do other than state that the case has not been proved. Two such examples may here be given; one as to alleged change of climate and the other as to a connection between the moon and the weather.

Many people believe that the British climate has undergone considerable changes in comparatively modern times. "The winters (or the summers) are not what they were when I was young," is a statement frequently made; but when meteorological records are examined, they show that the temperature, rain, snow, frost and like atmospheric phenomena are much the same at the present time as they were in the early days of the declining generation. Going back so far as trustworthy observations with meteorological instruments exist, no evidence can be found to justify the common belief that the climate of England has changed.

Tradition, and general impressions of elderly people, are, indeed, of little value in deciding whether any permanent change of climate has taken place. The only trustworthy test is provided by records of rainfall, temperature or other meteorological observations made systematically with suitable instruments. Such records go back for 150 years or so, and when they are examined critically they are found to give no decided indication of any progressive change, either for the better or worse. From an examination of old records, and of the long series of observations made at Greenwich, Sir John Moore was able to show to the British Association in 1908 that no appreciable change has taken place in the climate of the British Isles during the past six centuries.

The only definite association that can be regarded as established between changes of the moon and weather is that thunderstorms are slightly more frequent near New Moon and the First Quarter than near Full Moon and the Last Quarter; and it is noteworthy that this is overlooked completely in proverbial philosophy.

So far as earnest investigations have been carried out with the purpose of associating the weather with the various phases and positions of the moon, no connection has been found definite enough to be of service in the actual work of weather prediction.

Many educated people believe that rain follows great battles, the general opinion being that the noise of the guns or the burning of the gunpowder in some way affects the clouds, and causes them to precipitate their moisture. But as the

belief that great battles cause rain was held long before the invention of gunpowder, and is, indeed, mentioned by Plutarch, it is evident that the explanation is unsatisfactory, and only presents an ancient theory in modern terms.

So persistent and widespread is the fallacy, that as recently as the year 1911 a member of the House of Commons asked the First Lord of the Admiralty in Parliament "whether he would arrange for the fleet to carry out their heavy gun-firing practice round the coast at some other period of the year than in the middle of the harvest-time, when the resulting heavy rain may cause serious loss to the farming community." The reply was that "there is no evidence that the firing causes heavy rain," but this only meets belief with denial. Though the argument is not strictly scientific, perhaps the most convincing form of reply to those who profess to believe, or do believe, in the efficacy of gunfiring to produce rain, is to point out that the firing of big guns is carried on at Shoeburyness more frequently than at any other point on the coast, yet the mean rainfall at Shoeburyness, and on the coast of Essex generally, is the lowest in the British Isles.

It is commonly believed that during severe thunderstorms a bolt is sometimes discharged from the clouds and reaches the earth as a solid mass of stone or metal. There is, however, not a particle of material evidence in support of this belief. No thunderbolt originating in the clouds has ever been found, and none exists, whatever conviction may be held to the contrary. What are mistaken for thunderbolts as popularly understood are peculiar mineral objects, meteorites, or particles of soil or rock which have been fused by lighting striking the earth through them.

Almost every newspaper report of a volcanic eruption contains a reference to "flames and smoke" issuing from "the burning mountain," though this description of the phenomena is completely inaccurate. During an eruption there is practically no flame, and certainly none that can be seen except close to the crater; no smoke such as issues from a chimney is ever produced; and there is no burning in the ordinary sense of combustion as in a fire. These elementary facts have been taught to thousands of school children for the past twenty years, yet popular writers and journalists seem still to be unaware of them.

Uncritical observation and hasty conclusion are responsible for the reports of the occurrence of living frogs and toads enclosed in blocks of coal or other rock, or in clay many feet below the surface of the ground. A stone is being broken by a quarryman, a frog is seen hopping about close to the place, and forthwith the lively imagination of the labourer persuades him that he has seen it actually come out of a cavity in the rock. Dean Buckland made experiments for the purpose of ascertaining how long frogs and toads could live shut up in cavities of stone and excluded from air and food, with the result that most of them were dead within a year, and none survived more than two years. Yet frogs are alleged to have been found enclosed in rocks which, geology teaches, were deposited under water millions of years ago, and afterwards subjected to a pressure which has crushed all the fossils contained in them as flat as paper. If geology is right, the frog stories are utterly incredible. Or, as a distinguished geologist once said, the blow of the hammer that disclosed a live frog inside a block of stone without an opening would at the same time destroy not only geology but the whole fabric of natural science.

Writers in the popular press, and in technical papers also, frequently indulge in cheap sneers at what they call "scientific theory." In their minds, the man of science lives in a world far removed from the realities of life, and knows little of material things or practical possibilities. Nothing could be more incorrect than this view. With the exception of pure mathematics and metaphysics, every branch of physical and natural science depends for its progress upon practical work in the laboratory or the field. No one appreciates the value of experimental work more than the man of science, and no one is more critical of scientific theory. Whenever a theory is put forward in any scientific society, it is always subjected to severe attack from people most competent to point out its weaknesses; and in any case it only

survives until someone brings forward evidence which completely disproves it.

The public likes to believe that men of science predicted from theory that this or that thing was impossible which was afterwards achieved; and its literary guides usually associate a great discovery not with the man whose work in the laboratory or study led to it, but to the man who made a commercial success of it. It was the mathematical work of Clerk Maxwell and the scientific experiments of Hertz which produced wireless telegraphy, but to the popular press the only man responsible for this wonderful discovery is Mr. Marconi.

Very soon after Hertz had described his remarkable researches on the production and detection of electro-magnetic waves, the scientific world realised their importance. It was pointed out that as Hertzian waves possess the property of passing through fog or material obstacles they could be used for a system of wireless telegraphy.

The receiver used by Hertz was not suitable for telegraphic work, but a more practicable form was soon found, and was used in a lecture delivered by Sir Oliver Lodge before the Royal Institution in 1894, when the statement was made that the apparatus would respond to signals at a distance of half a mile. Two years later, Mr. Marconi filed a provisional specification of apparatus for signalling by means of electric waves.

Mr. Marconi not only saw that the laboratory experiments of Hertz might be put to practical use, but also proceeded to adapt them to a system of telegraphy through the ether. To his knowledge, confidence and daring must be ascribed the commercial development of wireless telegraphy, but his achievements were direct consequences of the scientific work of Hertz, Maxwell, Faraday and Henry. As he himself acknowledged in 1900:—

"The experimental proof of Hertz, thirteen years ago, of the identity of light and electricity, and the knowledge of how to produce, and how to detect, these ether-waves, the existence of which had been so far unknown, made possible wireless telegraphy."

When Wilbur and Orville Wright commenced their experiments in artificial flight, the only exact experiments they could find as to the resistance of the air to machines driven at different velocities were those made by the man of science, S. P. Langley. They were the pioneers of sustained flight with aeroplanes, and they have acknowledged that their confidence in the practical solution of the problem was derived from Langley and his work. They said:—

"The knowledge that the head of the most prominent scientific institution of America believed in the possibility of human flight was one of the influences that led us to undertake the preliminary investigations that preceded our active work. He recommended to us the books which enabled us to form sane ideas at the outset. It was a helping hand at a critical time, and we shall always be grateful."

It is constantly stated that artificial flight would have been accomplished long before if engines light enough to drive them had been available, but that is not the case. Flights with two, three or more passengers show that lightness of the motor is not the only consideration, and motors with equivalent weights were available ten years before the Wrights designed their man-carrying aeroplanes. It was by following the scientific guidance of Langley, and using mechanical ingenuity to extend it, that they were able to give practical effect to the desire of man to rise above the clouds.

In these and all related matters our guides and counsellors, not only in the periodical press, but also in less ephemeral publications, are, in the great majority of cases, unaware of the most obvious facts and phenomena of Nature, and have no acquaintance with the most elementary vocabulary of science, or outlines of scientific discovery. In everything that relates to the material universe around them, they are blind leaders of the blind; and they call their darkness light. They are indifferent to the wonderful growth and extent of scientific knowledge, and live in a paradise in which rounded phrases and curious fancies are of more importance than actual facts. In such a world a one-eyed man can be king. A more enlightened view will only be obtained when it is realised that an educated man must know something of science as well as of literature.

DISCUSSION.

The Chairman (Mr. Leon Gaster), in opening the discussion, pointed out the importance of this subject to the Circle.

Among those who took part in the discussion of Professor Gregory's paper were Mr. H. G. Wells, the well-known novelist, Mr. Chambers Smith (*Sanitary Record*), Mr. G. Rentell (*Electricity*), Mr. Ross (*Times Engineering Supplement*), Mr. Warrilow (*Electrician*), and Mr. H. Oakley.

It was pointed out that the standpoint of a daily newspaper in regard to such items was somewhat different from that of a purely scientific or technical journal. Some already made use of special expert writers on engineering subjects and in general they welcomed the co-operation of authorities in dealing with articles of special technical nature.

Some instances of errors in articles dealing with the use of electricity and gas were given, for example, a case in which "unaccounted for gas" was confused with "gas leakage."

Several speakers pointed out that the Circle, having amongst its members representatives of so many different technical journals, might be of assistance to the section of the daily press, which was not already provided with a staff of technical experts.

A resolution was subsequently passed welcoming this form of co-operation with the daily press. The suggestion was also made that articles of a scientific or technical nature should preferably be signed by a responsible journalist; or, if anonymous, should preferably be referred to a reader having a special knowledge of the subject. It was resolved that members of the Circle should be approached with a view to the preparation of a list of scientific, technical and commercial journalists prepared to act in this capacity.

TRADE JOURNALISTS AND THE BOARD OF TRADE.

At a subsequent meeting of the Circle of Scientific, Technical, and Commercial Journalists on March 23rd, the relations of trade journalists to the Board of Trade were discussed. The President of the Institute and other members of the Executive were present by special invitation, and members of the Circle representing a great variety of industries attended the meeting.

A paper was read by Mr. Charles H. Luke on "The Reorganisation of the Board of Trade and the British Consular Service." Mr. Luke gave some interesting figures for the exports of this country which had increased remarkably since 1870, but still to a far less extent than the corresponding trade in Germany. He suggested that in view of the importance of the interest involved the duties of the Board of Trade should be divided among three Ministries—namely, a Ministry of Commerce, a Ministry of Railways, and a Ministry of Labour. Mr. Luke also criticised the present system of nomination of the Commercial Attachés and Consuls, who, he suggested, should be British subjects.*

The Chairman (Mr. Leon Gaster) in opening the discussion referred to a very important blue book on the subject issued last year.† This contained some most useful information, and showed also that there were many diverse points to be considered, and that the question was a most complicated one. All would agree as to the importance of taking the present opportunity to organise our industries on more scientific lines.

Mr. Wilfred Stokes, representing the British Engineers' Association, said he had been working hard to get the Government to take up a scheme for the reorganisation of the Board of Trade. His plan, in outline, was to have a highly specialised and well-paid Board of Industry, with a President; a Council of fifteen or sixteen adequately remunerated members, representing our largest industries. Then there should be a number of qualified Trade Commissioners and attachés in our dependencies and Colonies. The cost would amount to a small sum in comparison with our present turnover, and ought very quickly to be recouped many times over in the increased trade such arrangements would undoubtedly bring about.*

In the discussion that followed Mr. S. J. Sewell mentioned that forty-eight hours after war broke out, he and a few other trade journalists had approached the Board of Trade and offered their assistance, but so far no definite action had been taken. Other speakers dealt with problems arising in the industries they represented, and the difficulties that had been encountered in securing the co-operation of the Authorities. Finally, it was agreed that Mr. Gardiner, the President of the Institute of Journalists, should be asked to approach the Board of Trade with a view to bringing about some form of co-operation with technical journalists. After discussion it was resolved to place in the hands of the Executive Committee in order to decide what further action should be taken.

* See "The War and the Parting of the Ways," by Charles Luke (Sampson, Low, Marston & Co., Ltd.)

† See Fifth Report of the Royal Commission on the Civil Service (1914).

* See "How to Pay for the War," by Wilfred Stokes issued by the British Engineers' Association.

VISIBILITY: ITS PRACTICAL ASPECTS.

NOTES ON A DISCUSSION OPENED BY MR. C. C. PATERSON AND MR. B. P. DUDDING AT A MEETING OF THE ILLUMINATING ENGINEERING SOCIETY, AT THE HOUSE OF THE ROYAL SOCIETY OF ARTS (18, JOHN STREET, ADELPHI, W.C.), AT 8 P.M., ON TUESDAY, APRIL 27TH.

Visibility depends, *first*, on the behaviour of the human eye and on the personal impressions of the observer; *secondly*, on the manner in which the object is illuminated; *thirdly*, on the nature of the object viewed and its background. The consideration of visibility, therefore, affects many problems in daily life, and the subject is of interest to the physicist, the physiologist, and the lighting engineer.

The following are some of the suggested points to be dealt with in the discussion:—

(1) The visibility of objects in close proximity to bright lights.

(2) The effect on the appearance of distant objects of (A) the colour of the objects themselves, (B) the colour of the light by which they are illuminated.

(3) The effect of contrast and the influence of the surroundings on the visibility of an object.

(4) The relative visibility of objects by direct and indirect light.

(5) The relative visibility of objects by natural and artificial light.

(6) The visibility of distant lights at night (coast lights, railway signals, illuminated signs, &c.).

(7) The visibility of objects illuminated by the beam of a searchlight or motor-car headlight.

(8) The connection between illumination and acuteness of vision and the conditions of visibility of strong and weak light.

ANNUAL CONVENTION OF THE ILLUMINATING ENGINEERING SOCIETY (U.S.A.).

The Ninth Annual Convention of the Illuminating Engineering Society in the United States will be held at the New Willard Hotel, Washington, September 20th—23rd inclusive. The Chairman of the Convention Committee is Mr. E. S. Marlow, of the Potomac Electric Power Company.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

VISIBILITY; ITS PRACTICAL ASPECTS.

Proceedings at the meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 8 p.m., on Tuesday, April 27th, 1915.

A Meeting of the Society took place on Tuesday, April 27th, MR. J. HERBERT PARSONS, M.B., D.Sc., F.R.C.S., being in the chair.

The Minutes of the last meeting having been taken as read, the Hon. Secretary read out the names of new applicants for membership as follows :—

Child, J. S.	The Edison & Swan United Electric Light Co., Ltd., Ponders End, Middlesex.
Elliott, J. W.	The Edison & Swan United Electric Light Co., Ltd., Ponders' End, Middlesex.

The names of applicants announced at the previous meeting on March 16th,* were read again, and these gentlemen were formally declared members.

The Chairman then called upon MR. C. C. PATERSON to read the introductory paper by himself and MR. B. P. DUDDING, entitled "**Visibility, its Practical Aspects,**" and the following took part in the ensuing discussion :—

MR. A. P. TROTTER, DR. W. J. W. ETTLES, MR. S. D. CHALMERS, MR. HAYDN T. HARRISON, DR. F. W. EDRIDGE GREEN, DR. W. WATSON, MR. J. S. DOW, and MR. P. J. WALDRAM.

MR. PATERSON briefly replied, and THE CHAIRMAN called for a cordial vote of thanks to the authors of the paper.

In conclusion THE CHAIRMAN announced that the **Annual Meeting** of the Society would take place on **Tuesday, May 18th.** After the transaction of the formal business there would be a discussion on "**Some points in connection with the Lighting of Rifle Ranges.**"

* *Illum. Eng.*, Lond., April, 1915, p. 161.

VISIBILITY.

Notes on Some Practical Aspects of the Question.

By Clifford C. Paterson and B. P. Dudding.

Introduction to Discussion at the Meeting of The Illuminating Engineering Society held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.C.), at 8 p.m., on Tuesday, April 27th, 1915.

The term visibility is used here in its broadest sense, viz., the ability to see an object or part of an object. We are accustomed to distinguish with more or less facility the objects which we look at each day, and as a rule, if our sight is not seriously defective, our seeing suffices for all practical purposes. We, therefore, are generally content to regard visibility as one of those phenomena which require little investigation and we devote attention to the provision of sufficient illumination to put the question of good seeing beyond doubt. It is only in certain circumstances when the illumination is necessarily low, or our power to distinguish objects is interfered with that it becomes necessary to examine some of the phenomena on which visibility depends.

Our opening of a discussion on this subject will take the form of an account of inquiries which we have made at different times into conditions which in some practical cases prevented good visibility.

These inquiries deal with some very different aspects of the question, and are in some cases, very incomplete. The reason is that the experiments described were not always undertaken with a view to a complete research on the subject in question, but merely to elucidate certain points which had a bearing on other work. We admit, therefore, a certain element of discursiveness and incompleteness and hope that some of the many omissions will be filled by others who take part in the discussion.

A particularly interesting aspect of the question of visibility on which unfortunately we have no experimental data is the art of rendering distant objects invisible by appropriate colouring and marking. The authors were once informed that if a donkey and a zebra were located in a distant field (and remained there to be observed) the zebra would become invisible long before the donkey. This effect was discussed in an interesting article by Col. F. N. Maude in " Land and Water " for January 30th, in which he gave an incident from practical experience of a regiment with pipeclayed belts and accoutrements being invisible by the side of another regiment which had equipment of a more uniform nature.

The following are some of the practical questions which have engaged our attention and which are dealt with below :—

(1) The visibility of distant lights at night.

(2) The visibility of objects illuminated by the beam of a searchlight or motor headlight.

(3) The visibility of objects in close proximity to bright lights.

(4) The relative visibility of objects by direct and indirect light.

(1) The Visibility of Distant Lights at Night.

Sailors and railwaymen have constantly to " pick up " and distinguish at night very small point sources of light. The visibility of such lights is often exceedingly low, particularly at sea. The lights may be white (yellow) red or green, and are necessarily exceedingly faint at the distances at which they have to be picked up. The white masthead light carried only by steam vessels is supposed to be visible at 5 miles, and the red and green side lights which are carried by all vessels, have to be visible

at 2 miles. The latter requirement under practical conditions can only just be met with oil burners, and the result is that if one ship is two miles away from another the respective lights are on the limit of visibility. We had occasion a few years ago to carry out an investigation* into the visibility of such point sources of light, and it was found that a definite value of visibility for practical use was 1·6 candles at 2 sea miles viewed on an ordinarily clear dark night. We further found that the inverse square law held rigidly for point sources of light when there was no atmospheric absorption, so that 1·6 candles at 2 sea miles looks the same as 0·000,000,12 candle at one meter. The apparatus we used was sensitive to + or — 5 per cent. and on an ordinary clear night no atmospheric absorption could be detected at distances of 2 miles.

Still considering point sources of light it was found that the intrinsic brilliancy of the source had no influence on visibility but that it is only the total flux of light emitted which counts. If we take two sources of light subtending less than one minute of arc, one of them one-sixteenth-inch diameter and the other approximately 1-inch diameter both having the same candle-power, they will both appear equally visible point sources from a distance of say 100 yards. When, however, a source of light or an object becomes large and subtends an angle which is appreciably greater than that which corresponds with the resolving power of the eye, the laws given above must no longer be assumed to hold.

Now the equivalent of 1·6 candles at 2 miles is not the smallest light it is possible to see under favourable laboratory conditions when the eyes are thoroughly dark adapted. If the light intensity is lowered to about one-quarter or one-fifth of this it may still be seen, at least intermittently, but the resulting value is on the threshold of visibility by direct vision. It is interesting then to try to estimate quite roughly what is the amount of energy which thus seems to be the minimum which will stimulate a single element of the central part of the human retina.

This may be calculated from a knowledge of the shape of the sensitivity curve of the eye at different wave lengths and the average distribution throughout the spectrum. For radiations to which the retina is most sensitive, viz., between 0·52 and 0·58 μ and for a pupil aperture of 7·5 mm. the amount of energy per second from a point source which will just stimulate direct vision when the eyes are dark adapted we find to be of the order of 10^{-15} watt.

An idea of the magnitude of this fraction of a watt may be obtained if we assume the distance from the earth to the sun to represent a watt. Then the amount of energy per second which will stimulate vision is represented by a distance of about two millimetres.

In what has been said earlier we have been thinking mainly of white light. Some interesting phenomena are revealed when the faint sources of light are coloured, particularly in relation to oblique vision. A green light will appear some five times brighter when viewed obliquely than when viewed directly, but a red light acts in exactly the opposite way. If we place a point source of green light in a dark room so that its visibility from the position viewed is equivalent to about 0·01 micro-candle at a meter, an observer will pick this light up when he is looking in some other direction and be quite conscious of its presence, but no sooner does he look towards it than it is gone. A faint red light on the other hand cannot be picked up by oblique vision at all, but when an observer has finally discovered it by direct vision he is impressed by how very visible it is. If he glances to one side however it disappears. The colour of faint lights is not distinguishable by oblique vision.

A very faint point source of white light is picked up more easily by oblique than by direct vision but the difference is not so marked as with green light.

(2) The Visibility of Illuminated Objects at Night.

This aspect of the question calls for attention particularly in the use of searchlights and motor headlights. What, for

* Paterson & Dudding, Measurements and Notes on the Visibility of Point Sources of Light. Proc. Phys. Society, London, Vol. XXIV., Oct. 1912. Proc. Optical Convention, 1912.

example, governs the visibility of a man walking along the road and being overtaken by a car? One often hears of the rating of headlights by the "length of the beam," but no definition has been suggested, as far as we are aware, which fixes the point at which a beam may be said to end. If the man on the road may be said to be visible at a certain distance what candle-power must there be to make him visible at twice that distance? Certainly more than 4 times because the man himself appears much smaller at twice the distance.

In order to obtain preliminary data on these points we made some experiments on a stright road bounded by trees and shrubs. Objects on the road were seen against a thick shrubbery in the distance so that for a person in dark clothes there was a minimum of contrast.

One way of making observations is to direct the beam of light down the road and cause persons clad in differently coloured clothes to walk away from or towards the light until they are pronounced to be just visible by persons behind the headlight viewing them against the dark background. This was done in a number of cases, with the following results:—

TABLE I.

Person observed.	Distance at which he was discerned (in feet).	Illumination produced by headlight at this point in foot-candles.	Surface brightness of person observed.
A	215	0·09	$0{\cdot}001_2$
B	253	$0{\cdot}05_6$	$0{\cdot}001_9$
C	260	$0{\cdot}04_6$	$0{\cdot}002_0$
D	265	$0{\cdot}05_6$	$0{\cdot}004_0$
E	365	$0{\cdot}02_4$	$0{\cdot}004_0$
F	470	$0{\cdot}01_3$	$0{\cdot}003_5$
G	610	$0{\cdot}008_1$	$0{\cdot}005_5$

It will be found from this table that except for observations D and E the surface brightness of a person divided by the distance is approximately a constant.

The results, however, obtained by such an experiment as this are necessarily somewhat indefinite and limited in scope, since the criterion used is not a good one, *i.e.*, the vanishing point of an object, and further there was a considerable variation between the projected areas of the different persons observed as viewed in elevation. An additional disturbing element was the presence of the motor headlight beam, which caused an intense illumination of the road in the foreground.

To place the measurements on a more fundamental basis the object itself was made luminous and the headlight beam eliminated altogether. We arranged a kind of sentry box on wheels, the open side of which was covered in by a mask. This mask was cut out in a form which had roughly the shape of a man, and translucent paper stretched across it. A number of small lamps were placed inside the box and fed from cells, the lamps being so arranged that they rendered the paper mask luminous. A pair of wires ran the whole length of the stretch of road with the ends connected to rheostats, at the point where the observers were located. By connecting these wires and rheostats in series with the lamps inside the box they could be dimmed down at will by the observers, and the brightness of the luminous object adjusted to any desired degree. Altogether the apparatus when used in the open on a dark night had rather the appearance of an alternately appearing and disappearing churchyard ghost. It was found again that the vanishing point was not a very definite criterion and that it would be better to fix up a "comparison object with which equality of visibility of the test object could be established at different distances. In the final arrangement (shown in Fig. 1), therefore, the brightness of the test object was adjusted until it appeared as visible as the comparison object. This comparison was made in a series of experiments with varying conditions. In one series the luminous object was wheeled to different distances from the observer, and a series of masks was used to vary its actual size, so that at each position the solid angle subtended by the object at the eye was the same. In this test where the area of the retinal image remained the same, constant visibility

was found when the brightness of the object was constant.

The above experiment was repeated but instead of using a self-luminous object, the object was illuminated by a headlight lamp and observed from behind the lamp. Under these conditions it was found that for the same sized object to be equally visible at the same distance its brightness had to be somewhat higher than when it was self-luminous. This increase of brightness required may be due to a change in the adaptation of the eye, and possibly to the change in the contrast between the object and the road.

It will be at once noticed that the observed readings so plotted distribute themselves about two straight lines. The sudden change in the slope of the curve occurs when the object viewed subtends an angle of about 10 minutes of arc. The experiments previously described on point sources of light showed that below the resolving power of the eye the visibility depends on the total candle-power, *i.e.*, the intrinsic brightness × area. For constant visibility, therefore, at a given distance, if we halve the area, we must double the intrinsic brightness. This is the condition that will be found to hold over the

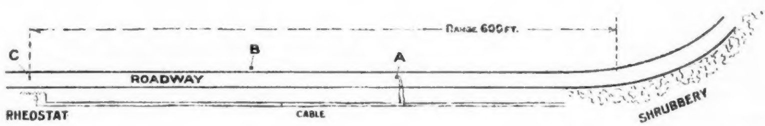


FIG. 1.—Arrangement of experiment on the visibility of objects at night.
A. Movable test object illuminated internally by electric lamps.
B. Comparison object (fixed). C. Observer.

In another experiment, the distance of the object from the observer was kept constant, but its dimensions were varied, keeping, however, the same shape, thus changing the size of the retinal image. This is equivalent, as far as the retina is concerned, to moving the same object to different distances, but it had the advantage of keeping the object in the same relation to the background against which it was viewed.

In this experiment the comparison of the object with the standard for equal visibility entailed the comparison of objects of different apparent size, but this was not found to be very difficult if the visibility of the comparison object was kept sufficiently low. The tests were repeated over a still wider range of size of object in the laboratory, and these are perhaps the most interesting of the series. The results are shown graphically in Fig. 2 where the log. of the linear dimensions and the log. of the brightness of the object at equal visibility are plotted.

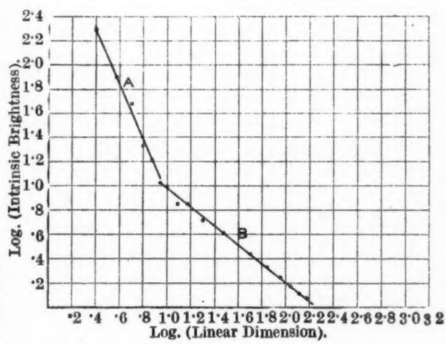


FIG. 2.—Curves showing the connection between linear dimension and intrinsic brightness of an object for constant visibility at a given distance.

Section A. Intrinsic brightness × (linear dimension)^2 = constant.

Section B. Intrinsic brightness × linear dimension = constant.

line A in Fig. 2 which is the part of the curve which deals with smaller objects. The portion B of the curve is for objects well above the resolving power of the eye* and our observations seem to show a different law connecting dimensions and brightness for constant visibility for such objects. The mean of several series of observations indicates that for constant visibility at a given distance if the area of the object is halved the brightness has not to be doubled but increased in proportion to $\sqrt{2}$.

We are therefore led to the following conclusion regarding visibility and dis tance that for an object subtending an angle less than about ten minutes of arc (about 1 foot at 100 yards), the brightness for equal visibility must be proportional to the square of the distance from the observer, but for objects subtending larger angles than this the brightness for equal visibility must be proportional simply to the distance between the object and the observer.

In putting forward this result we have to point out that it is not in accordance with the usual assumption,† but we have not been able to ascertain on what experimental work the usual hypothesis is based. This hypothesis is that the square law condition governing the visibility of small objects holds also for large ones. Blondel in a recent publication also discredits this ordinary hypothesis in connection with searchlights, and develops a connection between the brightness required to discriminate detail and the distance away of the observed object based on a theory of visual acuity.

Accepting then the results and conclusions we have outlined above we are able to see how the useful range of motor headlights increases with increasing intensity of the beam. It will be generally agreed that under the conditions of use of motor car headlights it is the larger size of objects which have to be discerned, *i.e.*, those appertaining to curve B.

If now a headlight enables an object to be discerned at 100 yards, by how much must the intensity of its beam be increased to enable the same object to be seen at 200 yards? For equal ease of discerning the obstacle at twice the distance, we have seen that the brightness of such obstacle need not be more than doubled, and to produce double the brightness at double the distance the intensity of the headlight beam must be increased 2×2^2, *i.e.* 8 times.

This may be stated generally as follows: The useful range of a motor car headlight is proportional to the cube root of the intensity of its beam.

It may be noted that on the usual assumption this multiplier would be 16, but our experiments only indicate such a large factor when the smaller class of objects is under consideration.

We have not experimented with searchlights over the greater distances with which they deal, but we see no reason why the above conclusions should not be valid so far as they apply to the problem.

(3) Visibility in the Presence of Bright Sources of Light.

This is merely the much discussed subject of glare, upon which a great deal has been written and a certain amount of experimental work carried out. What follows is not intended to be a general survey of the subject but merely some notes and experiments on one phase of it. Reference to the existing literature and data is not therefore contemplated. The original object was to obtain a criterion by means of which the interference with visibility caused by a bright lateral light could be measured. Two cases were under consideration:—

(1) The ability to see past an approaching car with bright headlights, (2) the interference with visibility when working in ordinary illuminations with a "light in one's eyes."

The upshot of the experiments was to show that with the very low illumination, prevailing at night and the consequent dark adapted condition of the eyes lights of the projector type very much less intense than motor headlights, are sufficient to render it impossible to distinguish any objects at all which are situated behind them. This result was not unex-

* The resolving power of the eye as a whole is generally assumed to be of the order of one minute of arc, but it is not a very definite quantity.

† Nerz. Searchlights: Their Theory, Construction and Application. Chapter 4.

pected, but we were surprised to find from a number of tests made under (2) with the intention of measuring the diminution of visibility of objects with an equivaient surface brightness of about 2 foot-candles and upwards under severe conditions of glare, that it was difficult to find any diminution of visibility at all. There is no doubt about the annoyance caused to an observer by the presence of bright lights in his field of view, but it appears that his ability to distinguish objects or detail is only affected when the brightness of such objects is relatively low. An effective demonstration of this is to arrange a white surface close to a bright lamp which can be switched on or off at will without affecting the illumination at the surface. This surface is illuminated by two sources, a central area being screened from one of them, thus producing a shadow. This contrast between the brightnesses of these two portions can be made as great or small as desired by regulating the position of the lamps, and the absolute brightness can also be varied at will. As the distinction of detail is largely a matter of discriminating small differences of shade, the glaring light, if it affects discrimination of detail, might be expected to prevent the observer distinguishing between the two areas when their brightnesses are nearly the same. As a matter of fact, a shadow contrast of 5% at an absolute illumination of 2 foot-candles was entirely unaffected by a glaring light of 20 candles placed 8 inches from it when viewed from a distance of 6 feet.

If, however, the equivalent surface brightness be reduced to 0·5 foot-candles the contrast was entirely obliterated under the severe conditions of the experiment.

Again, the following reading test was carried out by three observers. A page of ordinary printed matter was arranged with a constant illumination of 2 foot-candles at its surface, the lamp producing the illumination being placed close to the page and at a distance of 2 inches from one side of it. This light could be shielded from the eyes at will without changing the illumination at the printed surface. The time was noted which was required by each observer to read aloud, and as quickly as possible, one-half the page of printed matter when the light from the lamp was shining into his eyes, and then the time to read the second half with the eyes shielded from direct light. This was done with several pages of printed matter, with the following mean result:—

Observer.	Mean time of reading one page With glaring light.	Without glaring light
A	238 secs.	239 secs.
B	281 secs.	269 secs.
C	259 secs.	287 secs.

It was only when the illumination was reduced very much below 2-foot candles or when the ground work of the printed page had a dark tint that detail tended to become obliterated.

These results do not affect the question of the undesirability of glaring lights from other points of view but merely indicate that it is not easy to discover that glaring lights have very much effect on the visibility of detail under ordinary conditions of lighting.

It is not without interest to note that the value of equivalent surface brightness at which the diminution of visibility due to a glaring light begins to occur in these experiments corresponds with the value at which Koenig and Brodhun showed that Fechner's Fraction ceases to be a constant.*

(4) Visibility of Detail by Direct and Indirect Light.

The discrimination of detail in certain circumstances depends almost entirely either on shadow or on the direction of the incident light. Where the surface of an object to be viewed is uneven but uniform in colour, the only way in which the unevennesses can be shown up is by differences in the illumination of such surfaces caused by the different angles which they present to the incident light. If the unevennesses are very deep they will be shown up by the shadows which are thrown by the raised portions on to the surrounding surfaces. For instance the embossed lettering used on some

* Bell. "The Art of Illumination," page 5.

notepaper depends entirely on this action, and a sculpture in bas relief must obviously present a very different appearance according as it is illuminated by unidirectional light at glancing incidence or by light from a large source striking it mainly at normal incidence.

This question has a wide practical application in the manipulation of self-toned fabrics, viz., unicoloured fabrics with no natural contrasts. A person doing needlework with such materials depends for the discrimination of the detailed strands of the fabric on the small shadows cast by one strand on to the next and on the varying brightness over the curved surfaces of each individual strand. Both of these factors depend on the unidirectional character of the light incident on the material and the inefficiency of thoroughly diffused, viz., indirect light for such work is most marked. One of the authors has for upwards of ten years used indirect lighting for domestic use, and for a long time he ridiculed the often repeated assertion which was made that it was a most unsatisfactory light by which to do needlework and particularly darning. He has come to see, however, after experiment, that the contention is perfectly sound and that there is nothing so good as a unidirectional light giving harsh shadows for the discrimination of detail in needlework of all kinds. Indirect lighting with its soft shadows is in our opinion an ideal light for domestic use except in respect to this one particular.

DISCUSSION.

Mr. A. P. Trotter said that the help of oculists was needed to explain the physiological side of many of the subjects discussed by the Society, and that was particularly the case in the present instance. Engineers probably rarely attended meeting of ophthalmologists, but ophthalmic experts were very welcome to the meetings of this Society. He fully agreed with the authors about the disadvantages of indirect illumination. It always needed to be helped out with other lights. He had made some experiments in connection with the effect of a glaring side light on visual acuity. He expected to find that if the light was not too strong, acuity might be improved owing to the reduction of the size of the pupil. But he had come to the same conclusion as the authors, namely, that within limits no effect was produced. He was surprised that the accurate measurements of the authors had not discovered an appreciable absorption of light by the atmosphere.

The conditions of vision under extremely feeble illumination were interesting. He had not experimented with point sources but with large surfaces. He had to review a book on "N" rays, and he repeated the conditions laid down, with certain modifications and additions. One of these was to use one eye at a time. He found that after staring for many minutes at a feebly lighted screen, waves of darkness would appear to move across, more or less periodically as in the stereoscopic experiment with after-images described by Dr. Chunder Boés. The appearance of the screen was instantly altered by any sudden movement of the body and he could quite understand how willing pupils of an imaginative teacher might deceive themselves.

The work by the authors in connection with ships' lights was most interesting and important, and had been conducted with an excellent mixture of practical conditions with scientific method

Dr. W. J. W. Ettles: The notes on visibility to which we have just listened are very helpful and suggestive, because they are founded on a series of practical observations carefully recorded and any hypotheses applied to them can therefore be distinguished as such from the actual facts themselves, and can be weighed by those who approach the facts from different standpoints. It would occupy far more time than your courteous attention could be asked to extend, to traverse all the issues raised : hence I will only deal with one or two, and that in the spirit of helpfulness requested, and not by way of destructive criticism.

First then as touching the question of the threshold of visibility of distant lights at night. The contributors have made a point in their endeavour to

express this in terms of a unit of energy, viz., a watt. This is very useful because it brings out a point on which I have often insisted. This energy can only evoke sensation on the assumption that the space or emitted cone is re-collected to a proper apex on a percipient organ. Now, as a matter of fact, that seldom can obtain, if only by reason of the chromatic defects of our own eyes. In a quite normal eye the red rays are brought to a focus on the retina, but the blue rays cross in front and form a diffusion circle. As soon as the energy is diffused it falls below the stimulation point, and the source of light is not perceived. That is one reason why the green light is better seen; it is seen better because as soon as you get sufficient energy in the cone base to perceive it as green you have a relatively much larger colour area than is the case with the apex point of red. But I hasten to add that this is only one of the factors at work. Apart from its chromatic defects, the eye may have optical or refractive defects and both eyes may not be the same. Now a very small error of refraction will produce a great diffusion of a point, and its watt energy for stimulating a single cone in that area is therefore lost. Take the case of a man normal in one eye, and only very slightly short-sighted with the other. He will see a light as a point with one, and a disc with the other. As that light gets farther away the point energy of the disc will be too low, and he will see the light with the normal eye only. This is why a man with two good eyes has twice the perceiving power at extreme limits of vision, and why the Navy insists that each eye shall be perfect. The energy entering the sense organs is simply doubled. But remember this is only true of the limit of visual perception and not of degrees of luminosity, which can give rise to sensation over retinal cone areas of the diffusion circle.

Next, I will say a word about coloured point sources. The result of the experiment is that there is high sensitiveness for a small central area for red light with blindness of the periphery of the field; while with green light there is lowered central sensitiveness and largely increased perception over an extensive periphery. That is quite true. A "minimum visible" red can only be seen over an angular field of 20°, *i.e.*, 10° each side of the fixation line. Outside this it simply disappears, not only as red, but it disappears as a luminous point. Green is badly seen centrally, but peripherally it greatly increases in brightness, and can be seen in all parts of the field, *but*, and this is important, it cannot be seen as green. The actual area of colour perception is very small—quite as small as red. The real difference is that while red is blotted out altogether as a luminous point, green persists. The great restriction of our field for red is well seen in twilight, *e.g.*, the Volunteer Training Corps red brassard cannot be seen on a black coat in the evening. Again the greatly increased stimulus value of green is shown in the spectrum. If you close the slit down to the limit of perception, or if you project the spectrum on black velvet you will find that the most luminous portion is not now in the neighbourhood of the D line (0·58), but has shifted to that of the E line (0·53).

As to the limit of form perception, it has long been known to astronomers that binary stars could not be seen by the naked eye as discrete, unless their angle of separation was at least one minute. We know that vision depends on the stimulation of a retinal cone, and that a cone (foveal) is 0·002 m.m. in diameter. What is the size of the retinal area subtended by an angle of one minute? All rays cross in the eye so that we have two cones apex to apex at the nodal point.

Let X be the crossing point.

The distance of X from the retina is 15 m.m. Then

$$\frac{2\pi R}{360\times 60} = \text{the retinal area, or}$$

$$\frac{2\times 15\times \pi}{360\times 60} = 0{\cdot}004 \text{ m.m.}$$

i.e., the image corresponds to two cones. But if this is so we cannot have a visual acuity higher than one minute. On the other hand many persons, sailors, savages, hunters, &c., have extraordinary visual acuity. I know one man who can put down on a chart the bullet marks

on a card at a miniature rifle range of 65 feet. This vision must be represented by at least 2, if 1 be taken as normal vision. I think it is not a question of focus, for the man with V=1 and the man with V=2 may each be normal, but it is a question of the fineness of the foveal cones. Hence it is, too, that birds of prey have such extraordinary sight—their retinal elements are so slender.

Finally, I will touch on head-lights and searchlights, from the point of view of the person subjected to the glare. We have many factors, but some of the principal are these :—

1. Greatly increased sensitiveness. A match struck in a picture theatre will affect your seeing the picture for some time. Out of doors it is not noticed (in daytime). That is the same thing as adaptation. The sensitiveness to faint differences in luminosity means a vastly greater sensitiveness to great stimuli, so that they become blinding.

2. The positive scotoma or negative after image. If you have glanced for an instant at the sun you will have noticed the persistence for many minutes of a black or coloured after image. If the glance has been prolonged you may have it for hours, and if it has been foolishly prolonged there may be so-called "eclipse blindness" which may be permanent. This positive blind area projected in the field renders us insensitive to faint stimuli, and is a powerful factor in the annoyance and helplessness caused by glaring light.

3. We have irradiation. The retinal elements are all closely united, and stimuli overflow so that over-stimulation of one awakens its neighbours, and we think the object is larger. That is why an electric lamp filament is so much thicker when it is alight, why a heliograph mirror of 3 inches seems nearer 3 feet if you catch the flash at close quarters, and why, while visual acuity rises with illumination to a certain point, the irradiation causes such encroachment on the image that its detail is lost if the illumination is carried too far.

4. We have internal reflections. A veil of light from the various internal surfaces of the eye which covers, as with a light chaos, and so drowns the feeble emissions of the surrounding objects.

MR. CHALMERS said he was interested in the paper presented by Messrs. Paterson and Dudding, because of its relation to the question of visual acuity under reduced illumination.

In considering this problem he had come to the conclusion that the visual acuity depended at higher illuminations on complex optical conditions, but that a value was soon reached at which the visual acuity depended primarily on the quantity of light which was sent to the eye from each element.

To obtain normal visual acuity from each element of the Snellen chart it is necessary that each square minute of the chart should be observed, so that as the visual acuity decreases we can only identify elements which are larger and larger; as the illumination decreases we find that the total quantity of light which is required to show each element gradually decreases.

Tscherning quotes results by Dinalt which show that the quantity of light from the element gradually decreases until, when the element is between 10 and 20 square minutes, the quantity of light reaches a minimum value which corresponds to $\frac{\cdot 47}{\pi} \times \frac{1}{(3400)^2}$ candles $= \cdot 014 \times 10^{-6}$ candles, at 1 metre. This value compares with the values given in the paper for the least visible source.

The corresponding value calculated from the data of Koenig is 10^{-6} candles.

This seemed to indicate that a minimum quantity of light was required from each element, and that the element was of the order of from 10 to 20 square minutes in area.

He (Mr. Chalmers) therefore decided to investigate the question of the size of this element by noting at what illuminations elements of various sizes could be seen by direct vision with an eye adapted to darkness by avoidance of all bright lights, and arrangements are being made for the experiments. Among the questions he wished to investigate was whether the quantity of light would again increase as the element increased in accordance with Dinalt's figures, or continue to fall off as in Koenig's results.

These measurements have not yet been carried out; but the results given in Table II. of the paper are of interest in

this connection. If these results are confirmed in later measurements it would seem that the explanation is that the effects of light falling on the different elements of the eye are not strictly cumulative in their effects. Perhaps an electric analogy would indicate the effects to be expected.

If the energy were received by a group of thermo junctions, each connected to its own circuit. If each thermo junction received an amount of energy U per sec. the temperature would rise and a voltage of $E=\frac{U}{k}$ would result.

The current in the circuit would be $C=\frac{E}{R}$, R being the resistance, and the energy would be $EC=\frac{U^2}{kR}$.

If now energy U_2 were distributed over a number n^2 of these thermo junctions, each circuit would have a voltage.

$$E=\frac{U_2}{n^2 \cdot k}$$

and the final energy transmitted by each circuit would be

$$\frac{U_2^2}{n^4 \cdot kR}$$

and the total by all the circuits would be

$$\frac{U_2^2}{n^2 \cdot kR}$$

so that in order to produce the same effect it would be necessary to have

$$\frac{U_2^2}{n^2}=U^2, \text{ or } U_2=nU.$$

In other words, the *total quantity* of energy required would vary as the linear dimensions of the receiving area or the illumination would vary inversely as the linear dimensions.

This result is not in accordance with Koenig's observations, but seems to be in accord with Messrs. Paterson and Dudding's observations.

It is interesting in this connection to calculate the amount of energy which corresponds to the threshold as given by Aubert's determination. He finds that a sheet of white paper is just visible when illuminated by a candle at 200 to 250 metres.

Aubert's measurements of threshold give value $=\left(\frac{1}{200}\right)^2$ candles at 1 metre.

The quantity of light reaching the eye from each sq. minute of object is—

$$\frac{\cdot 25\ 10^{-4}}{\pi}\times\frac{1}{(3400)^2}\times\frac{\pi\times 9}{10^6}\times\frac{\cdot 1}{4\pi}\times T \text{ joules,}$$

where the pupil diameter is assumed to be 6 mm. T is the unit time assumed $=\cdot 1$ sec.

$$\frac{\cdot 25\ 10^{-4}}{\pi}\times\frac{1}{1\cdot 15\ 10^7}\times\frac{\pi\times 9}{10^6}\times\frac{\cdot 1}{4\pi}\times\cdot 1\times 10^7 \text{ ergs}$$

$$=\cdot 16\times 10^{-12} \text{ ergs}$$

this compares with Planck's quantum of energy $h\nu=3\cdot 9.10^{-12}$ approx., giving $h\nu$ for an area $=24$ sq. minutes.

In view of the very rough nature of the approximations for pupil diameter and still more for T, this is in agreement with the idea that for the threshold a quantity of energy equal to Planck's quantum must reach each element of the retina.

TABLE.

Dinalt,illum. in metre-candles.	Acuity.	Square minutes.	Product 1 and 3 ×·9 refl. coeff.
Large	1·50	·44	—
16·7	1·25	·64	9·6
1·5	1·0	1·	1·35
0·67	·75	1·78	1·07
·25	·50	4·00	·90
·12	·37	7·1	·77
·047	·3	11·1	·47
·028	·21	22·7	·57
·020	·15	44·4	·80
·016	·075	177·7	2·56

In connection with the questions raised by Dr. Ettles, Mr. Chalmers pointed out that the question of diffraction had to be taken into account in considering the visual acuity in cases of high illumination; that the receiving mechanism of the eye was capable of distinguishing very small angles was shown by the phenomena of stereoscopic vision. We had authentic observations showing that the eye could detect which of two objects was the nearer when the difference in the convergence angles was 5 or even 3 seconds. The eye must be able to appreciate these minute differences between the impressions re-

ceived by the two eyes. The explanation might be that when the images were not exactly similarly disposed to the cones the effect could be appreciated perhaps as a difference of light value and the muscular effort, to bring the two images to exact coincidence, appreciated. The effect was, however, a special one, and not ordinary seeing.

In connection with the observations on glare he would point out that for limited times and by special effort the eyes were able to overcome difficulties and see much more than usual. All trained observers appreciated this fact, but the eye was not capable of going on for long periods seeing those differences which were beyond easy vision, and unless observers were prepared to say that no evil effects in the way of earlier fatigue took place, the experiment would lose its value.

Mr. HAYDN T. HARRISON said that he was surprised to note that at the commencement the authors had defined "visibility" as "the ability to see an object." But it was obvious from their subsequent remarks that the term was interpreted in its correct sense, namely, the capability of an object of being seen.

This might not be considered an important point, but in fact it was. The term "illumination," for instance, is independent of vision, so the term "visibility" is independent of individual vision, and it was for this reason he was glad to note the average of several observers had been taken.

The term "dark adapted" was a new term, but it meant a very great deal. He himself had become dark adapted for certain experiments he desired to carry out, by going to sleep in the room in which he was going to carry out his investigations and waking up with the room darkened to the degree in which the experiments were to be carried out. With regard to the authors tests on the road, he rather judged that they decided the vanishing point by allowing the object to recede from the observer. He could not help thinking that if they had done exactly the opposite, and noted when the object became visible, the results would have differed because if one looked at an object receding one retained a mental picture for quite an appreciable period, whereas in the case of an object approaching you this was not so. The authors' tests on the effect of glare were very important. There had been a good deal of talk about glare, but this he believed was one of the first occasions at which an actual practical statement had been put forward as to when glare did affect the vision and when it did not, and he was glad to know that it did not really cause any serious effect when the surrounding illumination was above a certain degree. This was an effect he had always been inclined to believe because practically the only places in which there was any serious glare were cases of low illumination such as at night in streets where the general illumination was extremely low and in consequence the glare from street lamps and vehicles became very great. The point made in the paper as to the reliance placed upon shadows for seeing certain classes of objects of a monochromatic nature is much more important than many illuminating engineers realise.

This particularly applies to textile factories, workrooms and workshops.

Dr. EDRIDGE-GREEN said the question of an object being visible or not depended on the relative difference between the dark and light parts, a point which seemed to be generally overlooked. He had carried out experiments with a convex mirror, projecting various lights upon it of different sizes. He projected red, green, or blue, and then estimated how the light appeared. At certain distances it was found that the lights became white. The red was the most difficult, but when sufficiently small it became white when viewed with the central portion of the eye. The same thing occurred with the periphery of the retina. The small faint red light soon became invisible, whilst as the luminosity was increased it became red, and by increasing it sufficiently it appears red to the extreme periphery of the field of vision.

The periphery only of the retina was relatively colour blind. It was continually and erroneously stated that the Purkinje phenomenon was not found with the centre of the retina, though there were many who stated quite correctly that it was. If it were not found with

the centre of the retina a red which was of equal brightness with a blue in ordinary daylight would still appear similar when viewed centrally in a dim light, but the most casual observation would show that the red became darker than the blue when viewed with any part of the retina.

He had experimented with a hole in a door in which he fixed a blue glass and a red glass. By moving a lamp behind the glasses he was able to ascertain that, when it was close to the door, the red glass was brightest for all parts of the eye. When the lamp was moved away from the door so as to diminish the luminosity of the two glasses in equal proportion a point was reached when the red glass still appeared brightest for the centre of the eye, but the blue glass was the brightest directly the eye was moved a little outwards. When the lamp was moved still further away the blue glass appeared brightest for all parts of the eye, including the centre, but the difference became still more marked when viewed with the periphery of the eye. This might possibly explain the varying results obtained by different observers.

A simple experiment which proves conclusively that the photo-chemical stimulus is external to the cones may be made as follows. On arising in the morning arrange a mirror so that the sun is reflected from its surface, then whilst one eye is closed and covered with the hand, the other eye is opened and closed so that the image of the sun is visible for a fraction of a second: both eyes being now

FIG. 1.

FIG. 2.

closed and covered with the hands, a clear cut after-image of the sun is seen on a dark background (Fig. 1). It will be noticed that there is nothing else visible in the field of vision. If the head be now moved rather sharply to one side the after-image will be drawn out into a long sausage-shaped form with irregular knobs on it (Fig. 2).

If the head be sharply jerked we can obtain several after-images, plainly showing that the photo-chemical stimulus is movable in the retina, and therefore cannot be situated in the cones. I find these experiments succeed best in the morning immediately after sleep, probably because the processes of the pigment cells are retracted. If any reader find that he cannot see any of the subjective phenomena described by Purkinje or me, I would suggest that he select one of the most accurate observers of his acquaintance and ask him to repeat the experiment, without giving him the least clue as to what he is to see. If he describe the phenomenon as I have described it, it is obvious that we have obtained important confirmatory evidence. I find that whilst many older men fail to see various subjective phenomena they are rarely missed by the young.

Dr. W. WATSON said he had, during the last year or two, been making observations on the threshold of vision for different people. These experiments had a bearing on the question of the comparative visibility of point sources at the centre and periphery of the eye. He had been rather surprised to find that although the majority of people would agree with the authors of the paper, viz., that apparently the threshold for central region of the retina was much higher than the surrounding parts, yet there were a number of people in which this was not the case.

The authors' tests on motor lamps interested him because a few years ago he assisted in carrying out a number of tests on various motor car headlights. In that case he was studying the illumination produced by motor car headlights at different distances and attempted to determine the distance and the cross-section of the region at a given distance at which a given object was visible. He had, however, finally to fall back on photometry. It would be interesting to compare the range of such motor car headlights as were used in those days. Only white lights were then used, but the use of coloured lights was a problem of some practical interest at the present time. In the trenches they desired a method of illumination, and from experiments he had made he was fairly certain that coloured lights would give a good

effect under the conditions there, where everybody's eyes were perfectly dark adapted.

He was not quite clear, however, that coloured lights would give such a good effect in slightly foggy weather. It was generally agreed that the use of a yellow beam was an advantage in a motor car headlight or projectors in foggy weather and in some cases yellow glass was put in the field of the beam, whilst in others it had been proposed for use in the reflector.

On theoretical grounds, and as far as he could judge on practical grounds, the use of such a yellow beam might be an advantage. It was not so much that a yellow light or a red light in itself enabled one to see the object better. But most of the difficulty in seeing with a dark-adapted eye in a weak light arose from the fact that the sensitiveness of the periphery parts of the retina increased by many thousand-fold, and these peripheral parts were particularly sensitive to the blue end of the spectrum. When using a strong source of light in fog, a lot of light came back towards the eye, and that white light produced a sense of glare. If, however, we used a light which was weak in blue rays, the effect of this glare was very considerably reduced. In practice he found that a convenient way was to wear canary coloured glasses, and another way out of it might be to have a strip of ruby red glass across the top of the wind screen, the idea being to look through this on to the headlights of an approaching motor car. In this way one would not destroy one's dark adaptation in any great measure.

Mr. J. S. Dow remarked that the conditions affecting visibility in a feeble light were quite distinct from those prevailing at high illuminations. In the latter case the apparent brightness of an object seemed to be independent of distance, within limits. But in a feeble illumination the impression received by the eye seemed to depend on the total amount of light radiated from an object, and not only on its intrinsic brightness.

He could confirm, from his experience, what Mr. Paterson said as to the appearance of faint coloured lights by direct and oblique vision. It had often struck him that these phenomena might account for apparent inconsistency in evidence regarding the appearance of ships' lights at sea.

The appearance of small distant coloured objects, such as uniforms, seems to be affected by a number of different factors, *e.g.* the fact that a different part of the retina was utilised according as the object was near or far away; the contrast with the object's surroundings; and the effect of non-achromatism of the eye in "spreading" distant blue and violet. A soldier in a greyish-blue uniform possibly faded into the landscape, not only because of the small contrast, but also because the blue element could not be focused and appeared hazy. Another fact, pointed out by Prof. Blondel, was that the conditions of visibility in twilight might be reversed. Owing to the Purkinje effect a grey-blue uniform appeared almost white, but a red coat black in the night time. In a dark wood the scientific grey-blue uniform would probably be the more easily seen of the two. The effect of striping and spotting surfaces seemed to be to break the line of division and divide a large object into a series of small masses. He had heard it said that the striped colouring of the tiger was contrived by Nature to make the animal difficult to distinguish amidst the vertical lines of the jungle grass, whereas the spot of the panther (which climbed trees) had a similar effect amidst "dotty" foliage. He was told that chessboard marking of objects to render them indistinguishable dated back to Nelson's time, and was still known as "Nelson's checker."

It was interesting to note that there were two practicable methods of rendering objects indistinguishable. One method was to paint them to resemble the tone and colour of the objects in their neighbourhood (*e.g.* hulls of ships, hydroplanes, etc., might be painted grey): another possible method was to utilise mirror-surfaces by means of which the surroundings were automatically reflected towards a hostile observer. At the present time the study of these points seemed to be a very important one from the military standpoint. The utility of aeroplanes and submarines as scouts depends to a great extent on their escaping detection, so

that any researches which would result in progress in this respect would be well repaid.

Mr. Paterson's experiments on the visibility of objects on dark roads were most ingenious. At the present time there seemed to be a very pressing need for some method of defining the point at which a motor-car head-light became "powerful." He had heard of officers on leave, unaccustomed to the present regulations, being fined in one district because their lights were too bright, and in an adjacent district because they were not bright enough. It had been suggested that lights giving a "30-yard beam" were considered permissible. But who could say what such a definition meant? Physically there is no termination to a beam and practically only a gradual transition from brightness to darkness—a transition, moreover, which depends very much on the state of the atmosphere.

It would be very useful if some simple and definite test could be prescribed to be applied to confirm a personal opinion that the lights were too bright after the car had been stopped. Might not an electric torch equipped with a grease-spot or Leeson disc be used as a photometer-gauge for the purpose? Having decided the permissible brightness of lights, the photometer-gauge could be adjusted so that the spot vanished in the illumination obtained at a distance of say thirty feet from the car. Such a device would surely be a better test than personal impression, and might be an aid to the authorities in dealing with what was admittedly a difficult subject.

Mr. P. J. Waldram, speaking with reference to the motor-car headlight, said that the task of the constable was very difficult. If a motor-car were moving fast, the only thing to do was to measure the distance of certain objects in the road, and as the car passed see if these were illuminated at a distance of 100 yards, and ascertain by that means the length of the beam. If the car were stopped a good rough test was to walk across the path of the beam at a distance of 50 yards, and if one's boots and clothing were not distinctly illuminated the motorist might be generally allowed to proceed. There was not the slightest doubt that, particularly in the present darkened streets, a glaring motor-car headlight was, if not a source of danger, at any rate a source of great profanity to every driver it passed. It would appear, however, that the acuity of ordinary persons at night had been sensibly increased since the war. Things which they could not see when the streets were well illuminated were now easily discerned. That had been borne out by inquiries of constables who had been many years in the force. As to the checker pattern, he would suggest that the reason why this tended to make objects disappear was that at any considerable distance a checker pattern tended to prevent the eye from seeing the shape of the object. He had noticed frequently in outpost work that when viewing cows and men together, even against fresh green grass, if the cows had white spots or stripes it was exceedingly difficult to find out even with glasses whether one were looking at a man or a cow, and soldiers of many years' experience had confirmed him in this. He understood that the object of the extremely irregular checker patterns which were applied to the sides of forts and redoubts, and similar things, was to make a mass of smudges of colour, so that at any considerable distance the eye could not form any definite outline and see what the exact object was. One must not conclude, however, that decided patterns like pipeclayed belts or the red trousers of the French infantry were always an unmixed blessing. There were certain states of the atmosphere when a piece of red in a uniform stood out in a most particularly glaring fashion; whereas, at other times, perhaps only a few minutes earlier or later, that same red might cause the whole uniform to disappear.

Mr. John Darch (*communicated*):—In the third part of Messrs. Paterson and Dudding's paper dealing with visibility in the presence of bright and exposed sources of light, the authors conclude that "it is not easy to discover that glaring lights have very much effect on the visibility of detail under ordinary conditions of lighting." Indeed, the

authors have tabulated results which show that there is practically none.

There are two weaknesses in this conclusion :—

1. The mere test of time in reading a printed page is of little value unless the expenditure of energy and eye-strain are taken into account. One of the observers actually read quicker (which might be taken to mean easier) in the face of a glaring light than when it was shielded, which shows nothing more than that there was a greater expenditure of effort. Two friends may travel together, the one on a smooth footway, the other on a rough road : because they occupy equal time one cannot reasonably conclude that the rough road is as easy and good to walk on as the paved footway, or that it makes no difference to shoe-leather ; nor, if he on the rough road arrived first that the rough road was, therefore, easier and better to walk on than the footway. That represents the value of the time reading test. The broad fact remains that visibility is not only greatly impeded but is often rendered impossible in the face of a bright light, while eye trouble is the natural penalty for foolhardiness. Unfortunately, there is a reactionary class of mind in some lighting engineer, and architects that will eagerly seize upon such an insufficiently qualified statement as that to which I have taken exceptions in order to justify the obtrusive display of lights which characterise their lighting schemes.

2. The second weakness in the conclusion above referred to lies in the meaning of the words "ordinary conditions of lighting," and yet the authors state that their conclusions do not apply to an illumination of less than 2 foot-candles. Two foot-candles cannot be considered the lowest limit of ordinary lighting ; we may have this amount under a table lamp, but 1 foot-candle is thought by many to be quite brilliant for ordinary purposes and the average is less. The authors' conclusions, therefore, are likely to be misapplied, particularly by those who have a hazy notion of the luminous intensity of a foot-candle. But, again, the intensity of the illumination may go for nothing, for 10 foot-candles to a person working on black material or striving to distinguish detail in dark walls, pictures, &c., is less than 1 foot-candle to those engaged on white subjects, and in such cases the shielding of a light immensely improves visibility.

Visibility is the *raison d'etre* of the art of illumination : it is the kernel of the whole question, the only proper objective of the lighting engineer. It is not what can be made visible under sustained effort, but how the objects of daily life can be seen and fully appreciated with the same ease and pleasure that one experiences in open daylight or on the stage of a theatre.

Mr. J. G. Clark (*communicated*) :—Time did not permit me to make a few remarks on Messrs. Patterson and Dudding's paper at the meeting on the 27th instant ; I would therefore like to submit a few observations in writing.

I was extremely interested in the experiments which indicated the effect of glare upon visibility. The conclusions drawn from them by the authors are that the presence of naked lights do not materially affect visibility for illuminations above 2·0 foot-candles. This conclusion is confirmed by inquiries I have made at different times regarding the personal experience of workmen. I have found them sometimes working with a unit of about 60 candle-power just above and a little in front of their foreheads. They did not seem to mind it.

There can, however, be no question of the discomfort that is produced by bright naked lights in or near the field of vision. This is admitted by the authors. I am constrained to think, however, that this discomfort would in turn lead to impaired visual power if the exposure to the naked light were prolonged, say, half an hour or more. I do not see any statement in the paper of the period of exposure during the experiments recorded in Table II., but from practical experience I strongly believe that the "time-factor" is an important one and as it is one which invariably exists in practical work, it is worthy of careful consideration.

It might be (and I think probably is) a fact that whereas bright naked lights near the field of vision do not affect visual power the discomfort and fatigue following on exposure for, say, half an hour or more would indirectly reduce the visual value of a given degree of illumin-

ation. Perhaps the authors can throw some light on this aspect of the question of glare.

I was glad to see the question of direct *versus* indirect lighting dealt with although there are still some aspects of the question that need elucidation.

In a paper read before the Society by Mr. V. H. Mackinney and myself, the effect of an extension of the area of the luminous source upon the shadows produced by it was dealt with. It was shown experimentally how the size of the shadow of a given object extends as the area of the source increases until, when the source becomes of infinite area, the shadow becomes invisible, not because it has disappeared but because it has spread itself everywhere: it may be described as "shadowful" not "shadowless." Further, not only is the *size* of the shadow increased but the *contrast* between adjacent parts of the surface containing the shadow decreases (see page 137, THE ILLUMINATING ENGINEER, 1913), and as it is this *contrast* which gives definition to the shadow it would follow that "visibility" which depends on light and shade is greater with "direct" than with "indirect" methods. An illustration of the effect of contrast in its relation to visibility can be seen in the military flat-crowned cap. The conspicuousness of this seems to be entirely due to the *sharp contrast* in the illumination of the crown as compared with the other parts and the background. When the crown is rounded or dome-shaped it does not appear nearly such a good target as when flat, although the amount of illumination may be just the same or even more. Presumably the explanation is that the illumination on the rounded cap is graded and is therefore rendered less visible by the absence of sharp contrast.

Visibility by shadow contrast exists in many factories and workshops, and for this reason I am glad it has engaged the authors' attention.

There is, however, another aspect, namely, the visibility of written or printed matter. From observations I have made visibility by shadow contrast seems to have no practical significance here, and for this reason I have come to regard "indirect" and "direct" lighting as of equal value for reading and writing purposes, that is, 3 foot-candles (say) of indirect illumination is equal to 3 foot-candles of direct illumination provided the eye does not wander from the working or reading surface. If the eye does wander it encounters in the case of "indirect" lighting the bright surfaces of the walls and ceiling, which seem to that extent to reduce the visual value of the illumination of the working surface when the eye returns to it.

It seems, therefore, from an industrial and commercial point of view that the great loss of light that is occasioned by indirect methods is unjustified.

The "softness"—that is, lack of sharp shadow contrast—of indirect lighting makes it very pleasant for use in art studies, and in fact in any place where its softness is appreciated. The loss of light in such cases becomes of secondary importance.

The CHAIRMAN (Mr. J. Herbert Parsons) congratulated the Society on the excellent paper of Messrs. Paterson and Dudding, and on the very interesting discussion which had resulted from it. The question of the visibility of point sources of light was one of great importance and Mr. Paterson's work had been of great use to a recent Committee of the Board of Trade on Sight Tests for the Mercantile Marine.

The subject was of still greater importance at the present moment. He was surprised to hear that there was no appreciable absorption at 2 miles on a clear night. He believed that Mr. Paterson's minimum energy determination agreed fairly well with previous observations by Eyster and Boswell. Owing to physiological variability of sensitiveness absolutely concordant results could not be expected. The disturbing effect of bright lights in the field of vision and the visibility of detail by direct and indirect light had been attracting much attention from the industrial point of view before the war broke out. He would like to remind them of the excellent work of Cobb in America on the former topic. There were many points in the discussion which he would like to refer to and in some cases criticise.

The Authors' reply (*communicated*): We desire to express our pleasure that the discussion which we have initiated has led to so many interesting and helpful contributions to our knowledge of the subject of Visibility. We have also to thank those who joined in it for the kind treatment which they accorded to the very incomplete notes with which the discussion was opened.

We are specially interested in Mr. Chalmers' valuable contribution and to find in it a theoretical confirmation of the change we have found in the visibility law when the object has appreciable dimensions. We hope he will develop further and publish the details of the work outlined by him in this discussion.

Several of the points raised by Drs. Edridge Green and Ettles are too physiological in character for us to feel able to express definite opinions on them.

With regard to the first point raised by Dr. Ettles, it is, we think, necessary to remember that the image of a point source of light can hardly remain stationary on any one cone, but must be moving about rapidly over a number of cones, never, however, covering more than one at any instant. The eye in some way, however, sends to the brain an impression of a single point source, and if so there might be ground for supposing that a point source slightly out of focus would cause the same integrated stimulation as one that was in focus.

When considering the question of visual acuity it should be borne in mind as Dr. Watson implied, that it is not a physical problem only, and that cases of extraordinary acuity might be ascribed to psychological causes.

In reply to Mr. Harrison, we did actually make observations with persons approaching the car light as well as while receding from it. This should have been made clearer in our notes of the experiment. As regards the use of the term "dark adapted" this is the name given to a phenomenon well-known to all workers on the eye, and has been used in literature on physiological optics for some while. The phenomenon, however, is one, the importance of which is not, we think, sufficiently appreciated by many illuminating engineers at the present time.

We note with interest that Dr. Watson has examined persons, the foveal portions of whose eyes are more sensitive to faint white lights than the peripheral portions. This is certainly abnormal and it would be interesting to know if the colour vision of these people was otherwise normal.

Both Mr. Dow and Mr. Waldram referred to the effect produced by colouring objects in irregular chequer patterns. We would suggest that if objects having the same overall surface brightness are viewed against a background having a surface brightness not very different from that of the objects, then the object with an irregularly chequered surface would be the less visible, but that the same does not necessarily hold when the contrast in colour or surface brightness is more marked.

We agree with Dr. Dow that it is very important to have a definite criterion when stipulating the permissible strength of motor car headlight beams.

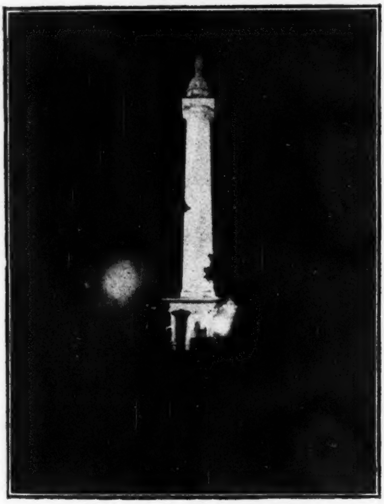
Both Mr. Clark and Mr. Darch, together with Mr. Chalmers point out that we omit all mention of fatigue after prolonged work under glaring conditions. In our remarks we stated that we sought a physical method of readily measuring diminution of visibilty due to "glare" and indicate the lines on which the experiments were made, showing that we were not successful in obtaining such physical measure. The question of eye fatigue should certainly be taken into consideration in any comprehensive work on glare and we admit the incompleteness of our experiments in this respect. Eye fatigue is a physiological and psychological phenomenon and not at all easily measured in physical quantities.

We cannot accept Mr. Darch's contention that because an observer read slightly more quickly with the glaring light it necessarily follows that he used more effort. The difference in the time of reading with and without the glaring light was only that which would be observed when reading different pages of matter under the same conditions of lighting.

We have more sympathy with the latter portion of his contribution and should be sorry if our notes on this subject encouraged in any way the use of offensive systems where strong lights are located in the field of vision.

SHORT NOTES ON ILLUMINATING ENGINEERING.

LIGHTING OF STATUES AND MONUMENTS.



Washington Monument (Baltimore).

Francis Scott Key Monument (Baltimore).

In a recent article in the *Electrical Review and Western Electrician* F. M. Weller gives some photographs showing spectacular lighting at the Star Spangled Banner Celebration, which took place at Baltimore last September.

Some of the decorations took the form of festoons of lamps hung across the streets, but the two illustrations show a method which deserves to be more generally used on such occasions, namely, the use of concealed lamps to illuminate national monuments. The photograph confirms the practibility of the method, and it could easily be applied (in less troubled times than those prevailing at the moment) to such monuments as the Queen Victoria Memorial, near Buckingham Palace.

REED-WARE LIGHTING FIXTURES.

The illustrations show a novel form of a lighting unit which has been developed in the United States.* These Reed-Ware fittings are made in the shape of portable lamps, brackets, and chandeliers, &c., and even "indirect" bowls. They are naturally intended for sunny and unconventional rooms, porches, &c., and one would imagine that they would be specially useful for emergency lighting in garden fêtes, &c.

WHITEWASHED KERBS.

According to the *Star* an interesting expedient is to be used in London with a view to diminishing the inconveniences of reduced public lighting. The Commissioner of Police is asking local authorities to whiten the street kerbs, thus enabling the line of demarcation between pavement and roadway to be more readily distinguished by drivers of vehicles and pedestrians. Experiments are said to have proved the utility of this device, which one can quite well believe. For the main element in this case is *contrast*. Everyone knows that the danger of stumbling over a step is accentuated when its tone and colour are approximately the same as the surroundings. A well-whitened doorstep is undoubtedly safest.

* *Electrical Review and Western Electrician*, October 17th, 1914.

Reed-Ware Chandelier.

Reed-Ware Bracket Lamp.

Reed-Ware Fittings.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we are again extending the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

SINGLE LAMP REFLECTORS FOR SHOP-WINDOW LIGHTING.

In the January issue of THE ILLUMINATING ENGINEER reference was made to the increased " fillip " to concealed shop window lighting given by the restrictions imposed by the war.

We have just received from the **General Electric Co., Ltd.,** particulars of a new series of reflectors to be used with single lamps, which are claimed to be a great advance on the older less scientific types.

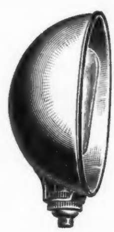
These reflectors effectually screen the lamp from the eyes of people looking into the window. The variety of shapes enables all sorts of problems to be tackled. Special features are the accessibility of the carrier ring holding the reflector in position, and the provision (in deep conical and parabolic patterns) for the necessary ventilation.

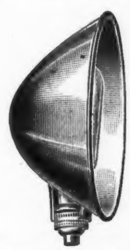
We understand that this effort at standardisation is attributable to the General Electric Company's Illuminating Engineering Department, who may be freely consulted on all problems in connection with shop lighting.


Shell.

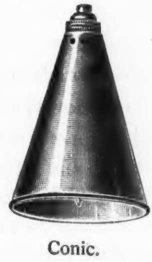

Fluted Scoop.


Plain Scoop.


Hemispherical.


Horizontal Parabolic.


Vertical Parabolic.


Conic.

HALF-WATT LAMPS AT SELFRIDGE'S.

Photo., by artificial light, of a corner of the Provision Department (ground floor) at Selfridge's, where the B.T.H. " Eye-Rest " System of indirect lighting with " Half-watt " lamps has been installed.

An interesting recent installation of " half-watt " or gas-fitted lamps has been carried out at Selfridge's by **The British Thomson-Houston Co., Ltd.,** from whom we have received the illustrations accompanying this note.

Owing to the brilliancy of these lamps, good shading is an essential point. The intrinsic brightness of the filament is said to be no less than eight times that of the ordinary metal filament lamp. This fact, and also the relatively high efficiency of these gas-filled lamps, encourages their use with indirect and semi-direct fittings, and these appliances have been installed on a considerable scale at Selfridge's (Oxford Street) in the new annexe.

The " Eye-Rest " system is installed on the ground floor and the first floor of this large block of buildings, and the effect is shown in the pleasing illustrations —reproduced, we are informed, from photographs taken entirely by artificial light.

The installation reflects credit on those concerned, the B.T.H. Illuminating Engineering Department, the contractors Messrs. Rashleigh, Phipps & Co., and on Mr. H. J. Clarke, who is in charge of Messrs. Selfridge's Building and Equipment Department. It is well worth a visit.

Photo. by artificial light, of a corner of the Grocery Department at Selfridge's (first floor), where the B.T.H. "Eye-Rest" system of lighting with "Half-watt" lamps has been installed.

A SECTION OF THE SHOWROOMS OF THE TOTTENHAM AND DISTRICT LIGHT, HEAT AND POWER COMPANY.

The two photographs accompanying this note were recently taken at the showrooms of the Tottenham and District Light, Heat and Power Company in the High Road, Tottenham. The exposure was made simply by the light of the lamps used for the ordinary lighting, and was arranged with a view to giving a correct representation of the ordinary conditions of illumination.

Fig. 1 shows a portion of the imposing room on the ground floor. The total floor area of this room is approximately 1,896 sq. ft. There are also a series of well arranged windows, lighted by concealed lamps so as to comply with the present regulations, and occupying a frontage of 119 ft. 6 in. This is essentially a working showroom. It is not given up to exceptional appliances, although typical lighting units of a docorative kind are on view. But the majority of the articles are such as would be used by the ordinary householder and we understand that, quite apart from the demand for factory lighting which has sprung up in the district owing to the large number of firms working overtime on Government jobs, there has been an excellent business done in ordinary interior lighting.

A characteristic of this showroom is its length, the part shown in the view being less than half of the total area. In the foreground will be seen a series of stoves mounted on a stand, on the left is a decorative coloured glass shade suitable for table-lighting, and on the right a silk shade suitable for lighting drawing rooms. In the background are a number of other lighting units which serve to show up the array of geysers and hot water appliances at the far end. As the photograph suggests, the lighting of the room is quite brilliant and the contrast with the somewhat gloomy war conditions in the street must be appreciated by visitors.

Lumina Bureau Photo.

A corridor at the offices of the Tottenham and District Light, Heat and Power Co., High Road, Tottenham, lighted by semi-indirect gas units.

Our second illustration was taken on the first floor. It shows an attractive example of semi-indirect lighting by gas, a method which is particularly suitable for corridor illumination, especially when there is an arched ceiling to " set off " the lights. The effect is soft and pleasant, and the brighter bracket lights at the far end of the corridor serve as a kind of

"climax" to which the eye is involuntarily attracted.

On another occasion we hope to refer to the window-lighting and to show how the illumination has been contrived to comply with the present lighting regulations, and yet to show off the contents of the window to advantage.

Lumina Bureau Photo.

A portion of the Showroom of the Tottenham and District Light, Heat and Power Co., High Road, Tottenham.

(*Photo. taken entirely by artificial light.*)

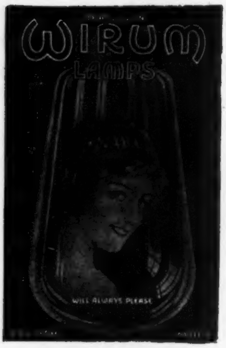
THE KEITH SYSTEM OF HIGH PRESSURE GAS LIGHTING.

Elsewhere in this issue appears an account of a paper by Mr. Broadberry giving an account of some high pressure installations at Tottenham and elsewhere, where Keith lamps have been used for factory lighting. At the present moment, when so many firms are working overtime on munitions of war, good industrial lighting illumination is appreciated. In a leaflet recently issued by the Tottenham and District Light, Heat and Power Company, it is remarked:—

"During the months of August and September we are inundated with lighting orders. If these orders were given three months earlier the mutual benefit is obvious. New factories spring up every day and require to be lighted at whatever season they are built. Some work night as well as day."

High pressure gas is recommended to "increase your output, improve its quality, safeguard the health of your workpeople and reduce your lighting bills."

A number of firms which are using high pressure gas lighting are mentioned, and a series of photographs, taken entirely by artificial light, are reproduced in order to illustrate the results obtained.



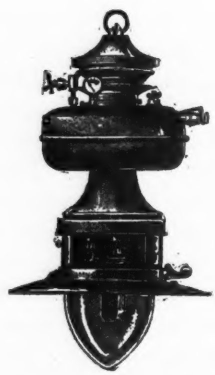
"Wirum" Lamps—An attractive Poster Stamp issued by the Brimsdown Lamp Works, Ltd.

This is the cover of a leaflet recently issued by the Edison and Swan United Electric Light Co., summarising the cost, advantages, and special applications of Ediswan Fans.

THE PETROMAX LAMP.

The development of emergency work in many districts owing to the sudden demands of the war has stimulated an interest in self-contained portable systems of lighting. The "Petromax" lamp, made by the British Graetzin Light, Ltd., is another example of the use of petroleum with incandescent mantles. Lamps giving 150 tc 1,000 candlepower and arranged to give light for 16—18 hours before requiring to be refilled, are now available. Like other lamps of the kind the Petromax lamp is started with a little spirit, but this only takes a few minutes. Special features are the simplicity of design and the "storm-proof" qualities of the lamp, which is claimed to be very serviceable for work in the open.

For emergency work and road-making operations for camps, goods yards, &c., portable self-contained lamps of this kind seem to have considerable advantages and it is not surprising to hear that makers of such apparatus are busy at the present time.



The "Petromax" Lamp.

A NEW REFLECTOR FOR INDUSTRIAL LIGHTING.

The design of good reflectors for factory lighting has much attention recently. Such a reflector is severely tested in practical use. Besides having satisfactory qualities as a distributor of light, it should be capable of being readily cleaned and should collect as little dust as possible; and if possible, the deposit of a certain amount of dust should not materially impair its efficiency.

In the new Holophane Industrial Reflector, illustrated herewith, the ingenious plan has been adopted of spinning an aluminium cover over the prismatic glass reflector, the metal cover merely resting on the apices of the prisms. As a result the natural high efficiency of the prismatic reflector is maintained, and the metal cover completely screens the upper surfaces of the prisms from dust. The inner surface of the reflector, being smooth polished glass, is also free from any tendency to accumulate dirt, and is easily cleaned.

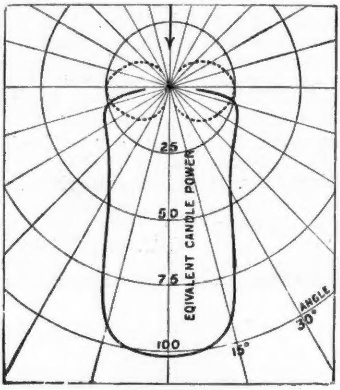
The advantages claimed for the reflector may be summarised as follows :—

1. The scientific light reflecting property of prismatic glassware is increased by the metal reflector.

2. It is easy to clean, both the inside and outside surfaces being smooth.

3. The reflecting surface does not tarnish after contact with the air.

4. The glassware, being protected by a metal cover, is secured from breakage.



Characteristic Light Distribution Curve.
- - - - Lamp alone. ——Lamp with No. 819.

Cat. No. 819.

This reflector gives four times the rated candle-power under the lamp.

HALF-WATT MAZDA LAMPS.

From the **British Thomson-Houston Co.** we have received a prize list of Mazda Half-Watt lamps, the cover being attractively got up with a view of the special standards for Half-Watt lamps used in Leeds City Square. The lamps are carried by statues, and the effect is distinctly better than that of the ordinary street column.

Messrs. Siemens Bros. Dynamo Works, Ltd., inform us that they have received an acceptance of their tender for the supply of carbon filament lamps to the Belfast Corporation during the ensuing 12 months.

CORRESPONDENCE.

WANTED—A NAME.

April 15th, 1915.

DEAR SIR,

I have been reading the very interesting discussion on Mr. Thorpe's paper. The remarks of Mr. Trotter on the use of the word " fixture " have once more reminded me that I have always had a strong objection to this term, but the persistent use of it by our American friends has almost made me accustomed to it. It is not much worse than the English word " fitting," but neither of these adequately describe a device for not only containing, but improving, the effectiveness of electric lamps, as a modern illuminating device should do.

The word " lantern " is descriptive, and more or less correct for the device used in street lighting and for commercial purposes, in which a globe contains the lighting units. It is after all a relic of the old lantern in which an open flame was used, and for which protection from the wind was essential.

I know of no suitable name, and think that a new one is justified. The French are a little better off, but they do not appear to have a word which is applicable to all types. " Garniture " (literally furniture, trimming, ornaments) is no better than ours; " lustre " is more suggestive, but of glare; " verrine " has a pleasant sound but refers to glass bowl fittings only. Can someone coin a word ?

Yours, &c.,

H. T. WILKINSON.

LITERATURE ON SEARCHLIGHTS.

Through the courtesy of Prof. A. Blondel we have received copies of several valuable contributions to the literature on the Theory of Projectors and Searchlights, and photometry relating thereto, which are as follows :—

Theorie des Projecteurs Electriques, by A. Blondell (Imprimerie Lefebure-Ducrocq, 82, rue de Tournai, Lille, 1894).

Sur les Principes de la photométrie geometrique (Assoc. Française pour l'Avancement des Sciences, 1896).

Sur les Propriétés Photometriques des Lentilles de Projection (Assoc. Française pour l'Avancement des Sciences, 1899).

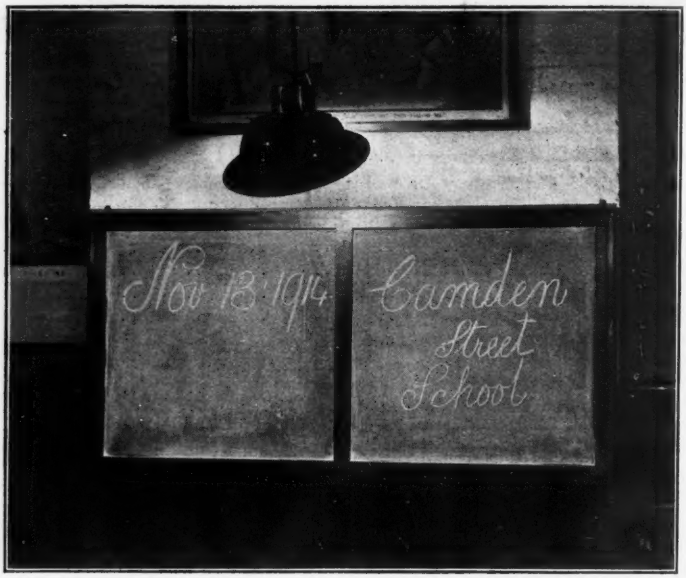
FEARED LOSS OF MR. G. MAURICE ON THE "LUSITANIA."

We learn with deep concern that Mr. George Maurice, the Manager of the Fittings, Heating and Cooking Department of the General Electric Co., Ltd., was on the " Lusitania," and it is feared that he has perished with the other victims in this terrible disaster.

Mr. Maurice was a member of the Illuminating Engineering Society, and was well known for his active work on behalf of the firm with which he was associated.

INDEX, May, 1915.

BLACKBOARD LIGHTING IN A MODERN SCHOOLROOM.



We are indebted to the courtesy of the Gas Light and Coke Co. for the above illustration, which shows the special blackboard lighting installed at the Camden Street School (London).

It is now recognised that the illumination on the blackboard should exceed that in the body of the room, so that the eye is naturally attracted to it and is not disturbed by the presence of adjacent brighter objects. It has become an invariable practice at the theatre for the stage to be brilliantly lighted and the auditorium to be darkened; similarly in the schoolroom the blackboard should be the centre of interest. It was suggested, in the Report on the Artificial Lighting of Schoolrooms issued by the Joint Committee of the Illuminating Engineering Society in 1914, that the intensity of blackboard lighting should exceed that in the rest of the room by 60 per cent.

It need scarcely be added that the source of light illuminating the board should be entirely concealed from the eye, so as to cause no glare.

We understand that the gas fitting shown consumes $3\frac{1}{2}$—4 cubic feet of gas per hour, and gives an average illumination on the blackboard of 5 foot-candles.